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UNDERSEA WARFARE TECHNOLOGIES

Advancing Undersea Capabilities

4

8

20

24

UNDERSEA WARFARE TECHNOLOGIES
Advancing Undersea Capabilities

On the Cover

U.S. Navy Divers display the American Flag out a dry deck shelter onboard an SSGN while conducting UUV testing operations.

Departments

FORCE COMMANDER'S CORNER

Vice Adm. Joseph E. Tofalo, USN
Commander, Submarine Forces

Undersea Warriors,

Greetings from Norfolk! Last issue we spoke about the Asia-Pacific, its dynamic environment, and the highly professional submarine forces that partner with us there. This issue covers the work of other crucial Submarine Force partners: the highly capable research and development organizations ensuring that we own the best systems and platforms. Much of this issue specifically discusses expanding the reach of those platforms with a new generation of autonomous undersea vehicles.

The time for these systems is clearly now. The Navy's *Design for Maintaining Maritime Superiority* points out how the increasing rate of technological creation and implementation drives the rapidly accelerating changes we face in the maritime environment. Our adversaries are aware of, and adapting to, these changes. We need to get faster in our operations, learning, processes, acquisitions, and innovation to outpace them.

Reading through this issue will give you a couple of examples of how we're doing just that; from the use of virtual and mixed reality for the purpose of production and training to advancements in Unmanned Undersea Vehicles (UUVs) and cognitive thinking Autonomous Undersea Vehicles (AUVs). Our record of success is growing as demonstrated by the shortened delivery schedule and reduced cost of the *Virginia*-class, which was designed in a virtual environment. The use of virtual technology has enabled the inexpensive delivery of immersive environments for the purpose of training, while augmented reality delivers amplifying details to allow for more effective and efficient real-time decision making. Taking it a step further, we're looking to equip AUVs with "intelligent autonomy" to carry out an independent decision-making process based on decades of corporate knowledge and then execute based on those decisions.

One thing hasn't changed though. It doesn't matter if the machine is manned or unmanned; any submarine sitting at the pier is capable of doing just one thing by itself; rusting. It is the people who design, test, build, operate, and maintain the machines who determine how effective they will be in combat. Make no mistake; combat is our business. I could not agree more with Rear Adm. Roegge's statement in this issue that, "the quality of our Submariners is the best it has ever been." The intelligence and resiliency of our Submariners and supporting partners allow us to make our force stronger. There's an old saying: "if you're not getting better, then you're getting worse." No matter where you are in the force, I challenge you to continuously improve the processes where you are today to produce a leaner, more flexible, more efficient and lethal force.

That is how we all get better.

That is how we will win.

Thank you for all you do. Keep charging!

J.E. Tofalo
J.E. Tofalo

> **"I could not agree more with Rear Adm. Roegge's statement in this issue that, "the quality of our Submariners is the best it has ever been."**

DIVISION DIRECTOR'S CORNER

Rear Adm. William "Bill" Merz, USN
Director, Undersea Warfare Division

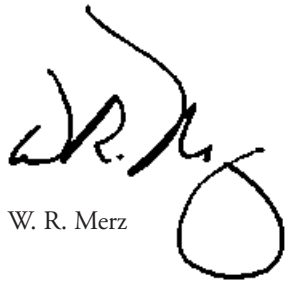Undersea Warfare Team,

Greetings all!

Since the last issue of *UNDERSEA WARFARE Magazine* there has been significant activity in the Pentagon regarding the future of the Navy under our new administration. Of particular note, across all communities, we have shifted our capability and investment discussions from community centric (e.g., submarines) to domain centric (e.g., undersea)—meaning the N97 team now has a voice in all effects under or from under the sea, including air and surface assets. This approach has broadened the understanding of overall warfighting capability and capacity and is providing focus on our most critical Navy capabilities. Aligned with my "mission discussion" last issue, N97 is the domain lead for both *Strategic Deterrence and Theater Undersea Warfare*.

> "In this issue you will have the opportunity to read about new technologies we're pursuing, including our family of unmanned vehicles, mixed reality solutions, cognitive computing, and fundamental shifts in our build philosophy."

Strategic Deterrence. Although there has been tremendous budget uncertainty across the federal government, the most critical programs continue to be supported. Through a committed effort by the Pentagon and Congress over the holidays, and despite the stalling of all other funding efforts, special funding was approved to transition the Ohio Replacement to an official program of record—a reflection of the common understanding of this program's importance to the nation. ORP is now a boat with a name and a sobering purpose; she is *Columbia*, and she remains our most valued national asset. This 12-ship class is now firmly planned as the phased replacement for the *Ohio* class and will take station as the foundation of the Strategic Deterrence Domain.

Theater Undersea Warfare. With the combination of the multiple blocks of *Virginia* class, the new *Columbia* SSBN, and our family UUVs, as a nation we are entering the most complex undersea vehicle construction era in decades. To ensure efficient merging of technologies and vehicles, we have inaugurated the *Tactical Submarine Evolution Plan*, or simply referred to as TSEP. There's nothing simple about it. This complex plan establishes the basis for quickly leveraging evolving improvements and revolutionary technologies, establishing the clearinghouse for inputs from the fleet, industry, and builders. A clear example of how this will be used is our intention to "up-arm" our SSNs by leveraging existing weapons to improve our lethality in multiple domains. Stay tuned.

In this issue you will have the opportunity to read about new technologies we're pursuing, including our family of unmanned vehicles, mixed reality solutions, cognitive computing, and fundamental shifts in our build philosophy. Also in this issue, RADM Fritz Roegge shares his insights as Commander, Submarine Force Pacific, a very active part of the world.

Keep up the great work out there; we're behind you 100 percent. You are part of the domain team that is expected to own the seas before and during any conflict, no matter the adversary, no matter the location. Wear that pin proudly. Like so many before us, the nation depends on our ability conduct its business far forward, with certainty.

W. R. Merz

CHINFO Merit Award Winner   Silver Inkwell Award Winner

LETTERS TO THE EDITOR

In keeping with *UNDERSEA WARFARE* Magazine's charter as the Official Magazine of the U.S. Submarine Force, we welcome letters to the editor, questions relating to articles that have appeared in previous issues, and insights and "lessons learned" from the fleet.

UNDERSEA WARFARE Magazine reserves the right to edit submissions for length, clarity, and accuracy. All submissions become the property of *UNDERSEA WARFARE* Magazine and may be published in all media.

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FROM THE EDITOR

As with the Submarine Force, we at *UNDERSEA WARFARE Magazine* are constantly improving our processes. We strive to recognize in our Downlink section the accomplishments of all Submariners. Therefore, we want to publish your successes as Submariners. If you are aware of achievements or awards that we are missing, please send us a note either via email or our Facebook page.

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CHECK IT OUT!

An updated Force Map Insert for 2017 can be found in the center of this issue.

by Lt. Tia Nichole McMillen, Submarine Force Pacific Public Affairs

Q+A with
Rear Admiral
Frederick "Fritz" Roegge

Rear Adm. Roegge is Commander, Submarine Force, U.S. Pacific Fleet and has served sea tours of duty aboard USS *Whale* (SSN 638), USS *Florida* (SSBN 728) (B), USS *Key West* (SSN 722), and command of USS *Connecticut* (SSN 22). Roegge most recently served as the director, Military Personnel Plans and Policy Division with a concurrent period as director, Total Force Manpower Division on the Navy staff.

In your mind, what is your role as Commander, Submarine Forces Pacific (COMSUBPAC)?

As a type commander, my staff is responsible to man, train, and equip Pacific Fleet submarines for their missions. Those missions are the same as the ones that Commander, Submarine Force, U.S. Atlantic Fleet (COMSUBLANT) submarines perform, but of course we tailor our efforts for the unique operating areas of the Pacific, whether in deep-water broad-ocean areas or in shallow-water high-contact-density environments.

COMSUBLANT and COMSUBPAC differ from other Navy type commands because of our operational command responsibilities that are in addition to our man/train/equip functions. Here in the Pacific, I command Task Force 34, responsible for Theater Undersea Warfare (TUSW) in the Eastern Pacific under Commander Third Fleet, and I also command Task Force 134, responsible for the strategic deterrent mission under Commander, U.S. Strategic Command.

COMSUBPAC is also the one type commander with Navy-wide man, train, and equip responsibilities for some unique undersea missions. These include our submarine escape and rescue capabilities under Submarine Squadron 11 in San Diego, Calif.; the fixed arrays and the Surveillance Towed Array Sensor System (SURTASS) ships of our Integrated Undersea Surveillance Systems (IUSS) under Commander, Undersea Systems in Dam Neck, Va.; the research and development programs such as Unmanned Underwater Vehicles under Submarine Development Squadron 5 in Bangor, Wash.; and our two submarine tenders now home-ported in Guam.

In order to achieve this, I provide guidance and set priorities, such as we did last year when we published our "Commander's Intent for the Submarine Force and Supporting Organizations."

This is sort of a "textbook" definition of my role, but I think a simpler way to describe it is that my job is to provide what our submarine crews need in order to be successful at the challenging missions we assign them and to help Sailors accomplish their own personal and professional goals.

The combination of this important work, our superb Submariners, and the fact that I wake up each morning in Hawaii, means that I clearly have the best job in the Navy!

What challenges do you see today in the Pacific Theater?

Our challenges are pretty clear from every newspaper's headlines and from watching the news banners scrolling across your favorite cable news program. Competition among nations often plays out first in competition on the high seas, and so there are many Indo-Asia-Pacific nations adding to their naval capabilities and, more specifically, their submarine capabilities. Russia is operating at levels we haven't seen since the Cold War, and they've modernized their force with new platforms like the *Severodvinsk* SSGN and the *Dolgorukiy* SSBN and with new capabilities like the Kaliber weapons system. China is expanding its capabilities and also the areas of their operations. They've deployed surface action groups around the world and even into the Bering Sea, and their submarine operations are similarly expanding in their reach. This year both North Korea

Rear Adm. Frederick J. Roegge, commander, Submarine Force U.S. Pacific Fleet, speaks to Sailors about the submarine force Commander's Intent during an all-hands call at Naval Base Kitsap-Bangor. Photo by Mass Communication Specialist 2nd Class Amanda Gray

and India launched ballistic missiles from submarine platforms, and around this region there are now more than 20 nations operating submarines or pursuing that capability.

With RIMPAC 2016 concluding, what lessons did we learn from the exercise?

We confirmed what we already knew: no matter what flag they fly, naval forces and their Sailors and Marines have much more in common than they have as differences. The most important commonality was the talent and professionalism of each nation's mariners and their focus on improving our ability to work together. This was no small task, as RIMPAC 2016 had 26 nations participating and brought 45 surface ships and five submarines to Pearl Harbor. As both the RIMPAC TUSW Commander and also as the submarine operating authority (SUBOPAUTH), we invested heavily in ensuring exercise safety, and I was pleased that we had no untoward events. The personal relationships that develop through such multi-lateral operations build trust, and we have long understood that, for trust to be an operational enabler, it must be built. You cannot surge Trust.

What role do our international partners play in the Pacific Theater in the Undersea Domain?

COMSUBPAC submarines benefit from the great partners, friends, and allies we share in the Pacific. Our boats and their crews benefit from port visits and logistics stops in traditional locations like Japan, Korea, the Philippines, Singapore, and Australia. This year we've also had submarines or tenders in Malaysia, Palawan, and Vietnam. This access is essential for us to maintain our boats at high readiness throughout their lengthy and demanding deployments. In return, we've had visits to U.S. home-ports from submarines from Japan, Korea, Australia, and Chile; and many more nations send Submariners to attend courses and use the trainers at our training centers in Pearl Harbor and in Guam. This not only gives our subs the opportunity to train against advanced and highly proficient diesel subs, but it improves our interoperability; and this is paying off now in increasing multi-national cooperation—and success—in TUSW.

What is your favorite memory or sea story from your junior officer or department head tour?

All my fondest memories are associated with great shipmates doing impressive things during challenging operations, and the common theme running throughout has been that I can't believe I get to do such cool—and important—stuff. Some of my favorite memories are overseas port visits—fun, taking green water over the bridge—memorable but not fun, dodging ferries through the Strait of Messina—challenging, surfaced officer of the deck on the midwatch at AUTEC—the night sky is awesome, surfacing through the ice—even more awesome, and of course every mission vital to national security—challenging *and* awesome.

How has the role of a Pacific SSN changed since you were a junior officer?

Our submarines have so much more capability now, and the quality of our Submariners is the best it has ever been. But our SSNs still rely upon the same core characteristics of stealth, mobility, endurance, and firepower. Our Navy and our nation still rely upon us to use those attributes to demonstrate warfighting prowess that will deter aggression; we must be able to operate undetected anywhere in the world, and be able to hold at risk the things that potential adversaries hold most dear. To that extent, our role hasn't changed at all.

What is the greatest lesson you learned as a junior officer?

To be myself. I originally thought there was some textbook approach to being a division officer or a watch officer that had to be followed. Over the years I've learned that there are many different ways to be a successful leader, and trying to act against your own nature in an effort to emulate someone else's approach is usually as unsuccessful as it is unnatural.

Where do you see the Pacific Submarine Force going in the future?

I think our future is informed by our past. On December 7th in Pearl Harbor we remembered the successes and the sacrifices of our World War II Submariners. After that attack, Chief of Naval Operations Admiral Harold Stark gave the order to "EXECUTE AGAINST JAPAN UNRESTRICTED AIR AND SUBMARINE WARFARE," and our submarines were the only forces able to immediately begin war patrols. They carried the battle across the Pacific and into Imperial Japanese home waters while our fleet was repaired. And although submarines made up only 2 percent of our entire Navy, they sank 30% of all Japanese warships and 55% of all Japanese merchant ships sunk during the war.

But today's Submariners are another greatest generation, and what we do every day is adding to the proud history of our Submarine Force. Undersea superiority is just as important to our national security today as it has been throughout our past, and we're making significant investments in modernizing our submarines, in adding capabilities like UAVs and UUVs, and in our people through initiatives such as those in Sailor 2025 in order to ensure we maintain that superiority.

As potential adversaries develop capabilities designed to thwart the United States, the risk to aircraft and ships grows daily, but the Submarine Force retains the unique ability to go undetected anywhere in the world and to hold at risk the things that potential adversaries hold most dear. So should the future hold another Pacific competitor to challenge the United States, then in that future it will once again be the Pacific Submarine Force that will lead the way. That makes this an incredibly exciting time to be a Submariner, and an incredibly important time for our Submarine Force to maintain its superiority. Our Navy and our nation should expect no less.

Rear Adm. Frederick Roegge pins "dolphins" onto Seaman Steven Kongsy while visiting the Blue crew of the *Ohio*-class ballistic-missile submarine USS *Louisiana* (SSBN 743).

Photo above by Petty Officer 1st Class Amanda R. Gray

Corporate America and Academia Partner to Develop New Undersea Technology

by Lt. Cmdr. Michael J. Huber, Military Editor

Much of what makes the U.S. Navy so effective at defending U.S. interests at home and around the world is a result of its longstanding relationships in the private sector. Industry and academia continue to contribute to the Navy's unmatched strengths by conducting research and development in cutting-edge technologies. They work hand-in-hand with us to apply those advancements and breakthroughs to naval applications, making what was once the domain of futuristic science fiction a reality for our Sailors today.

In this issue we provide a glimpse of such futuristic technology and the processes by which it gets put to use by America's Navy. The following four articles examine how industry and academia leverage their technological expertise on behalf of your Navy so that we can meet our goals and objectives in protecting Americans and our allies and friends overseas. Following are two articles from academia partners, followed by two more from partners in industry.

The first article comes from Johns Hopkins Applied Research Laboratory (JH APL), delves into the realm of augmented reality and virtual reality, both facets of what is called mixed reality. These technologies have made significant progress lately, and JH APL is bringing them to bear on Naval training applications. Training Sailors by using these technologies was cost prohibitive a decade or so ago, but the commercialization and growing popularity of the hardware and applications is driving costs down and making training in potentially high-risk or complicated activities accessible and safe, not to mention effective.

The second article comes from from Penn State University's Applied Research Laboratory. The authors describe how intelligent autonomy can be applied to Navy UUVs using the existing submarine command structure and crew knowledge base to give it intelligent autonomy. This will give the MANTA decision-making abilities similar to those of a live watch stander crew.

The third article comes from an industry partner, Riptide Autonomous Solutions, which has developed a small but capable unmanned undersea vehicle (UUV), that can be fielded in large numbers at low cost. The small UUV, along with other sized vehicles, has the potential to address the rapid global advancement of submarine technology by future potentially adversarial governments. It will do this by providing an adaptable UUV platform that can be deployed in large numbers, extending sensor ranges and acting as force multipliers. This platform is promising enough that Navy labs have begun to take deliveries of the small UUV for Navy-specific experimentation and testing.

The fourth article is from an industry giant that got its start by selling the Navy its first submarine, the USS *Holland* (SS1) in 1900. General Dynamics Corp.'s Electric Boat Division gives us a look at how independent research and development processes are used to make previously impossible technologies and capabilities, once only the province of imagination and wishful thinking, not only possible but a reality. From digitally displaying the flow and force characteristics of propeller crashback to better study and understand its effects and improve propeller design to developing and integrating the *Virginia*-class Block III's Large Aperture Bow array to save space and money and improve the array's capabilities, Electric Boat's independent research and development processes have helped to make these and other significant advancements possible.

It's often difficult to see clearly what's in our technological future, particularly in the area of submarines, for which secrecy and stealth are vital to mission success. Without divulging too much, we've pulled back the curtain a bit in this issue to give you just a peek at some of the things that the Navy, in cooperation with our academic and industry partners, are bringing to our very near-term future.

by James D. Miller The Johns Hopkins University Applied Physics Lab Submarine Warfare Program Area

Mixed Reality for Submarine Applications

Recent technology advances in high-resolution displays, motion sensing, and compact computing/micro-processing have changed the way people interact with computing. Immersive environments can now be delivered inexpensively to anyone who owns a smartphone. A small additional cost of a head-mounted display can take that immersive presentation to the next level. This immersive computing technology is referred to as Mixed Reality (MR).

Mixed Reality covers the spectrum of technologies that have been maturing rapidly over the last decade. The continuum of MR spans from the physical (real) world to the fully virtual and includes Augmented Reality (AR) and Virtual Reality (VR). MR adds computer-generated objects/environment to varying degrees to enhance a user's knowledge or understanding and enable interactive behaviors within the MR experience. DoD has long been investing in technologies that enable the range of MR experiences. Initial investment resulted in lab-based prototypes that supported expensive training and held the promise of future operational use. However, this R&D investment is on the verge of bearing real operational fruit with the commercialization of key components, significantly decreasing cost.

Virtual Reality (VR) is a fully immersive synthetic 3D environment where users can explore and interact with simulated entities within that environment. There are key advantages to using VR in military applications. VR experiences are impactful and memorable for the end users, making them excellent training and mission rehearsal/exercise opportunities. VR can take people to places that are difficult to access due to cost or physical travel limitations. Furthermore, VR affords fewer resource constraints than those that real-world exercises may incur. The synthetic worlds provide safety and an analytic envi-

Fleet Integrated Synthetic Training/Testing Facility (FIST2FAC) hosted technology demonstration for training. Photo by John F. Williams

ronment for testing relationships or procedural interactions. VR has the advantage of providing very high fidelity worlds that are immersive, impactful, cost-effective, accessible, and safe to use.

Technology is continuously enhancing

the state-of-the-art; however, there are limitations to reaching the point where VR is mainstream, even in applications for which it is well suited. Not all human senses are fully immersed; tactile feedback is not typically available and is challenging to integrate. For some applications, like damage control response, smell is also critical and not fully integrated into VR applications. Mobility is limited due to the need to be tethered to hardware that can support high-end graphics processing. It is also difficult to fully suspend belief as a user's hands and body are not natively represented in the VR world. These last two key limiting technologies are currently being tackled and may soon be overcome with programs like Intel's initiative, Project Alloy. While technology continues to advance, the understanding of its impact on people and effects of use for extended periods of time are not fully tested.

Lt. Jeff Kee explores the Office of Naval Research (ONR)-sponsored Battlespace Exploitation of Mixed Reality (BEMR) lab located at Space and Naval Warfare Systems Center Pacific. BEMR is designed to showcase and demonstrate cutting edge low cost commercial mixed reality, virtual reality and augmented reality technologies and to provide a facility where warfighters, researchers, government, industry and academia can collaborate.

One of the biggest challenges to getting the technology deployed is the burden of developing quality 3D content.

Another immersive technology, Augmented Reality (AR), maintains the physical world and blends new information into the user's field of view. One of the first commercial applications of AR technology was the yellow first-down line in televised football games. AR affords much more mobility than a full immersive VR and does not always require head-mounted displays. Many AR applications run on mobile devices like smart phones and tablets. AR provides information quickly and exploits or discriminates objects in the real world. This ability makes AR an excellent fit for navigation applications. AR also allows a level of limited tactile feedback as it can work with real-world objects. Additionally, AR worlds generally don't require the visual fidelity of VR to recreate the environment and thus need less graphical processing to be effective.

Similar to VR, AR is not without its own limitations and drawbacks. Many AR devices are less capable graphically, result-

> **"Mixed Reality covers the spectrum of technologies that have been maturing rapidly over the last decade. The continuum of MR spans from the physical (real) world to the fully virtual and includes Augmented Reality and Virtual Reality."**

ing in lower fidelity and lower-quality 3D imaging. The AR mobile devices are also more limited in power and battery life. AR devices sometimes have difficulty synchronizing the real world with blended objects. AR devices rely on multi-sensory input to display correctly (e.g., wireless motion, graphics, range, and light distortions). AR applications are prone to over saturation or information overload and as a result can distract the user from core objectives, and a user-centered design approach is key to successful implementation. As with VR, the impact on the user is not yet fully researched and tested. As with VR, the

biggest hurdle with AR is the ability to develop and map quality content.

The enhancements to the physical world and simulation of real-world effects lend MR to things that are seldom practiced in the real world, things that are complicated and hard to understand, novel experiences that are difficult to practice (AR for maintenance), and things that require suspension of belief to be effective (VR for fire drills). MR has shown to be effective, however, in improving human performance through immersive training, realistic mission rehearsal, and enhanced information presentation.

Columbia University's Augmented Reality for Maintenance and Repair (ARMAR)

Many years of MR research and development has shown great promise in improving mission performance. Research has demonstrated the effectiveness of AR and VR to various applications that are directly related to submarine operations. Education studies have found that learning time decreases with virtual simulations and that AR is an effective educational medium. These studies found that AR allowed mechanics to locate tasks more quickly and, in some instances, with less overall head movement than when using current maintenance aid systems or an enhanced version of the system currently used by U.S. Marine Corps mechanics.

Applying MR capabilities to future submarine fleet applications has the potential to improve operator effectiveness, situational awareness, training, and mission rehearsals.

Operator effectiveness

AR enables overlaying information on a user's environment based on access. This can enhance team collaboration and communication by enabling teams with different levels of security to be co-located and reduce the information flow bottlenecks. Additionally, as seen in maintenance applications, AR allows for overlay of task steps that are complicated, rarely done, and difficult to recall.

VR allows for immersive collaborative environments for individuals who are not co-located. A shared environment extends the Common Operating Picture concept and would allow for collaborative interaction of the environment; when one individual interacts with an entity in the environment, the other collaborative participants would also experience the change.

Situational Awareness (SA)

Extensive design and development has been conducted for displaying submarine and submersible SA displays for post-mission analysis as well as real-time tactical decision aids. Although some 3D technologies are beginning to be used, most of these displays are still 2D. As fleet submarines are required to conduct more operations in concert with other manned and unmanned systems, the opportunity to use VR and AR in multi-source intelligence and other SA tools will improve operational effectiveness. VR and AR have the potential to improve SA across the operational functions in a submarine and other platforms. One example of using AR in operations for enhanced SA is the Navy's Divers Augmented Vision Display (DAVD) research program. DAVD is a high-resolution, see-through, head-up display embedded directly inside a diving helmet. This NSWC Panama City-developed prototype can provide divers with real-time visual display of sonar, text messages, diagrams, photographs, and video.

The VR technology development is much further along than the research to explore new ways of showing SA data using these devices. The cost effectiveness of emerging hardware allows for more research into the best ways to leverage AR and VR technologies to support SA in submarine operations.

NSWC Panama City Divers Augmented Vision Display (DAVD)

Training and Mission Rehearsal

Research in learning demonstrates that ideal mediums of learning are based on the learning objective. For example, you might want to have supplementary information hover over a physical system component; AR is well suited for this application. The training requirement may instead be to practice a given physical task to a specified level of proficiency; this type of training is suited to VR where that physical task can be simulated in an immersive environment full of risk where actual missteps don't result in real danger. A current Navy example of this is the Virtual Environment for Submarine Shiphandling Trainer (VESUB). VESUB is a VR-based computer system using virtual environment and head-mounted display technology. The trainer provides the Officer of the Deck (OOD) trainee individual instruction in the knowledge and skills necessary to successfully and safely pilot and maneuver a surfaced submarine through restricted waterways avoiding collisions and grounding.

All MR technologies are possible and useful for training and mission rehearsal; the issue is determining where to apply them. The commoditization of these technologies offers an opportunity for the Navy to match the right training environment (SA, VR, AR) based on training objectives. This facilitates development and deployment of effective training environments that leverage the best of all technologies.

These technologies are mature and, when coupled with physics-based modeling and simulation capability, have proven to be a very effective way of delivering training for a modest investment. MR-based training is software-intensive to allow for rollout of the training quickly. An incremental/agile strategy of focusing on the most critical (or deficient) learning objectives has worked well for these systems. This approach has also been synergistic with existing but more expensive training assets (e.g., hardware trainers / real platforms) as VR is cost effective for reaching a large audience and preparing students for the most effective training possible in expensive or unique training assets.

VR technologies have the potential to improve the suspension of disbelief required for providing engaging training products. Several VR trainers already exist; however, additional research in determining how these technologies could be best applied to training in the naval special operations community is needed. VR training is much more feasible given the significant reduction in hardware cost. For example, it is known that experiential learning improves acquisition of skills; these environments enable low-risk experiences that may be applicable to operations. VR would provide an opportunity to rapidly and inexpensively research, develop, and test training technologies that can be deployed across the service, allowing for skill retention and career progression. Sailors could take tests in a low-risk, distributed learning environment providing experiences applicable to high-risk operational activities. This would enable a research initiative with the aim of transitioning to operational training.

The Navy and submarine community recognize that MR has great potential to impact operator effectiveness and mission readiness. The Office of Naval Research, in collaboration with Space and Naval Warfare Systems Center (SPAWAR) in San Diego, have created the Battlespace Exploitation of Mixed Reality (BEMR Lab) to showcase cutting-edge technology for the warfighter, researcher, government, industry, and academia. This Navy research partnership expanded recently with Rear Adm. Frederick "Fritz" J. Roegge, the commander of Submarine Force, U.S. Pacific Fleet (COMSUBPAC), officially opening the COMSUBPAC Innovation Lab (iLab) on November 7, 2016. In addition to SPAWAR, the iLab partners with the Naval Sea Systems Command (NAVSEA) New Training Technologies Program Office. This facility allows for Submariners to rapidly prototype with commercial visualization technologies.

MR capabilities are at a technological point where significant impact to operations can be made. Near-term and longer-term research to understand the operational effectiveness and how human performance changes as a function of technology is still needed to achieve full potential.

References

Morie, J.F; Virtual reality, immersion, and the unforgettable experience. (2006). Stereoscopic Displays and Virtual Reality Systems XIII, 60551X, Proc. SPIE 6055, doi:10.1117/12.660290.

Haque, S., & Srinivasan, S. (2006). A meta-analysis of the training effectiveness of virtual reality surgical simulators. Information Technology in Biomedicine, IEEE Transactions on, 10(1), 51-58.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented Reality Trends in Education: A Systematic Review of Research and Applications. Journal of Educational Technology & Society, 17(4), 133-149.

Haque, S., & Srinivasan, S., 2006; and Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk., 2014.

Henderson, S. J., & Feiner, S. (2011)

Virtual Environment for Submarine Shiphandling (VESUB) Trainer

by Mr. Mark Rothgeb and Dr. John Sustersic

The Coming Revolution in Cognitive Autonomous Undersea Vehicles

With the advent and successes of the MQ-1 Predator, RQ-4 Global Hawk, MQ-9 Reaper, and other Unmanned Aerial Vehicles (UAVs), expectations for vehicles with extended reach capabilities have been growing within the warfighter community for Autonomous Underwater Vehicles (AUVs). The Predator's significant impact in the Middle East operational theatres beginning with Afghanistan and Pakistan is largely due to the ability to achieve safe standoff for the warfighters. It provided reliable operation while executing relevant precision strike missions. The Chief of Naval Operations in a congressional report in February of 2016 stated:

> "Autonomous Undersea Vehicles are a key component of the Navy's effort to improve and expand undersea superiority. These unmanned vehicles will be able to operate independently from or in cooperation with manned vehicles…"

The U.S. Navy is working to make significant advances in unmanned vehicle autonomy, which traditionally has been limited to scripted operations with little to no intelligent decision-making. Aggressively pursuing solutions to extend the capability of the Navy using unmanned systems that are truly autonomous will increasingly remove humans from the loop and decrease the burden on human cognitive resources.

The challenges of the maritime undersea environment are unique and particularly severe as noted in the Defense Sciences Board's task force report.

> "…technology cannot overcome certain physical limitations of the marine environment, essentially mandating greater autonomy"

While AUVs can perform waypoint operations, avoid basic obstacles, keep from grounding, and activate payloads, their autonomous decision-making is limited and often non-existent. To be operationally relevant for most missions, AUVs must be able to perform multi-dimensional decision-making in an environment that simultaneously considers all factors including weather, sea state, water column characteristics, fishing areas, merchant lanes, geopolitical boundaries (territorial waters and economic exclusion zones), shipping lanes, threat active and passive detection, countermeasures, degraded self-health, information assurance, GPS denial, mission timeline constraints, water space boundaries, and energy management.

These real-world challenges are routinely resolved by submarine crews, who have 100 years of corporate experience in dealing with the manifold unpredictable realities of the ocean environment and underwater operations. The coming generation of AUV systems will need to leverage this expertise and knowledge and embed it in intelligent autonomy that will enable platforms to perform relevant missions. These systems will require intelligent multi-dimensional decision-making abilities akin to the human watch team on a submarine.

Simultaneous with the increasing mission need for intelligent AUVs is the rapid acceleration of Artificial Intelligence (AI) technologies, spear-headed by industry and technology leaders within government laboratories and academia. An anecdotal example of this is the race by auto makers to produce autonomously operating vehicles. This has resulted in significant industry investment as they anticipate the market potential. Similarly, Apple (Siri), Microsoft (Cortana), Google (Google Now), Facebook (Fasttext) , and many others are working toward semantic understanding for improving human interaction with their systems.

Because of the convergence of increasing AUV mission needs and rapidly advancing AI technologies, the Navy community is on the verge of creating AUVs with greatly increased operational capability and usefulness. Deep belief networks, genetic algorithms, learning systems, cognitive architectures, and other AI techniques will provide critical capabilities in leading this advance.

A promising next-generation autonomy system has been developed through funding by the Office of Naval Research SwampWorks to develop a framework in which cognitive technologies and crew knowledge and expertise from Subject Matter Experts (SMEs) can be naturally combined. As a starting point, the team determined that incremental improvement in existing fielded autonomy technologies, many of which date back to the 1980s and 1990s, would be insufficient to handle the decision complexity and ambiguity of real environments that future missions require. A clean sheet approach was taken to incorporate cognitive decision-making and the capability to enable learning mechanisms as an intrinsic part of the architecture from the ground up. The team created the "Multi-agent Architecture for Natural and Trusted Autonomy" (MANTA) system, which directly incorporated the submarine watch stander crew as its model for autonomy as depicted in Figure 1.

Using the submarine watch team as a model for autonomy provided significant benefits.

- Functional decomposition and modularity of the system is natural in that each member of the watch stander team is well defined and coherent, which is fundamental to software architecture.

- Knowledge of the crew and its experience naturally fit into the appropriate correlated agent.

- Interactions between watch team members (software agents) is well defined in the submarine "Interior Communications Manual" (ICM), and these natural language litanies form the basis for the messaging interfaces and agent interaction.

- Delegated authority provides back-up and overwatch as the Commanding Officer (CO) delegates to the Officer of the Deck (OOD) and on down. High-level monitoring and correcting occurs when needed. This adds to resilient and safe operation when incorporated within autonomy.

- Levels of constraints are inherent in the team hierarchy, providing layered operating margins for mission execution. For example, water space is allocated from fleet to the submarine. Within that allocated waterspace the CO directs the navigator to define the ships operating envelope (where in the Ocean the submarine will operate) to provide safe transit and operating constraints, and within that the OOD works to stay near the Path of Intended Motion.
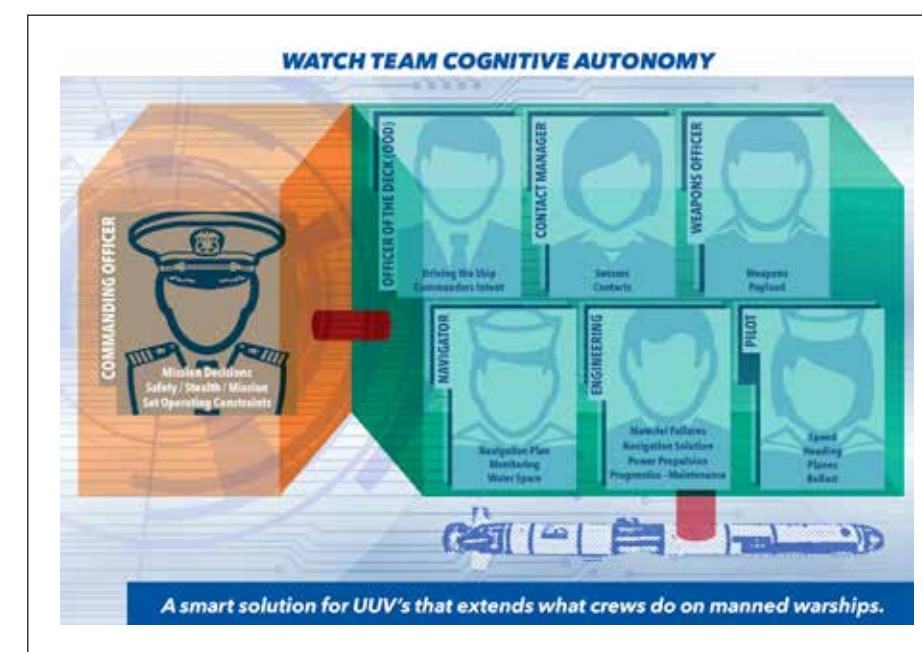

Figure 1. MANTA incorporates a software agent for the primary roles of the Submarine Watch Team.

Using this same approach in software provides layered safety and makes it robust with regard to the dynamic environment.

- Collaborative operations between manned and unmanned systems is natural in that the vehicle is tasked with mission objectives, timelines, and priorities within its capabilities just as a human or another manned system. This means that no specialized interface is required between manned and unmanned systems.

- Trust in autonomy (an often overlooked but critical attribute for autonomy acceptance) is attained as tasking and interactions are all natural language. Explanation of decisions is provided by each agent as it would be in the watch team providing transparency.

- The approach is open-ended (not brittle) in that submarine crews are the most capable autonomous underwater system (albeit manned). As we evolve to capture their decision-making and expertise in cognitive and learning systems, this architecture provides a natural landing pad within the relevant correlated watch team agent.

- As a longer term goal, algorithms for sub-

marine operations may be naturally ported to autonomy, and autonomy capabilities can be used to up-level the submarine crew over time and be used for training. For example, an evolved capable navigator agent may be used to train navigators or could even augment the submarine crew as an intelligent advisory agent.

A crucial feature in MANTA's approach is the ability to apply the correct technology to the agents within the system and to enable incorporation of future technologies without breaking the model. Figure 2 shows that each agent is composed of a cognitive layer, a computational layer, and an interactive layer. The cognitive (thinking/deciding) layer, a piece missing in operational AUVs today, enables multi-dimensional decision making to take place using cognitive technologies that are well suited to simultaneously handle the variety of considerations mentioned earlier, accomplishing the mission within environmental, threat, time, and capability constraints.

Architecture layers can be replaced as new technologies evolve. For example, MANTA started using Robot Operating System (ROS) for the intercommunications layers. Mid-stream in development ROS was replaced with ZeroMQ,

an alternative messaging method. This was accomplished without impacting the computation and cognitive layers. Soar is currently used for the cognitive layer, but the layering allows replacement with a different cognitive engine such as Adaptive Control of Thought-Rational (ACT-R). An individual agent may also use a different cognitive engine than the rest of the agents. In addition to the intra-agent modularity, the inter-agent modularity in MANTA allows any agent to be replaced so long as the new agent conforms to the agent intercommunications.

To incorporate cognitive technology with the SME knowledge base, a cross disciplinary team composed of computer scientists (engineering and AI), cognitive psychologists, active duty Submariners, and mathematicians was used to develop the prototype system that was regularly tested throughout the summer of 2017 on a small IVER-3 AUV.

The resulting autonomy architecture breaks the paradigm currently used in today's AUV systems and is indicative of the coming revolution in intelligent autonomy.

While the cognitive layer is new with regard to fielded systems, leveraging the vast submarine operational SME knowledge base provides a jumpstart toward advancing development of knowledge-based systems that can be effectively used in smarter, fully autonomous AUVs. The rapid pace of innovation of cognitive systems and the capability to inject advancements into an architectural framework will continue to further enable better handling of the dynamic and unconstrained environments typical of the modern battlespace. Moreover, using a submarine tactical center as the fundamental design model for the AUV is a game changer. It enables a natural inclusion of cognitive decision-making functions at all levels (every software "role") and enables the evolution of more robust AUV systems.

Figure 2. The layered approach in each agent allows naturally appropriated technologies to be applied in each layer.

by Jeffrey M. Smith

The Next Big Thing in Undersea Warfare May Be Micro

At a time when the U.S. Navy is pushing to develop and field its planned Large Displacement Unmanned Undersea Vehicle (LDUUV) and developing an accelerated demonstration plan for an even bigger Extra Large Displacement UUV (XLDUUV), one new technology start-up sees opportunity at the opposite end of the spectrum. Riptide Autonomous Solutions has introduced a new product dubbed a micro-Unmanned Undersea Vehicle (UUV) and it has started to make deliveries of this new class of UUV into the Navy development labs and to commercial and academic clients.

UUVs have a history dating back to 1957 with the Special Purpose Underwater Research Vehicle (SPURV) developed by the University of Washington's Applied Physics Laboratory. Academia and special government programs drove the early decades of research, but advancements were slow. Throughout the 1960s, 1970s, and 1980s, more rapid growth came for the Remotely Operated Undersea Vehicle (ROV) market. It is commonly said that the ROV's single largest advantage is that it has a tether, which provides for the ability to remotely power the vehicle as well as provide operator-in-the-loop communica-

tions and control via real-time access to the vehicle's sensor suite. It has also been said that the ROV's single largest disadvantage is its tether, as it limits the range of the vehicle to the tether length and the tether and tether handling equipment can weigh 10 to 20 times more than the vehicle, making deployment and logistics a challenge.

In the late 1980s and early 1990s, advancements were made by several academic and scientific research organizations in the design of lower-cost, autonomous vehicles that leveraged available technologies in commercial computer processing coupled with lower-power ROV sensors. Several large U.S. defense contractors such as Boeing, Lockheed Martin, and Northrop Grumman led major program development efforts for the Navy during

Retired ACT Specialist Dan Lawrence hand launching a Micro UUV

Examples of various Micro-UUV configurations

this period. With declining defense budgets in the early 2000s, smaller UUV startups established their footing on smaller procurements for U.S. and international defense, scientific, and commercial clients.

Since the 2010 timeframe, the market has grown steadily as the U.S. Navy released three large ($50M to $100M) multi-year programs for Autonomous Undersea Vehicles (AUVs) and oceanographic gliders, commercial oil and gas expanded to deeper fields off South America, Africa, and Asia, and environmental monitoring requirements grew. Recent market studies suggest the current UUV market globally is about $2B, and that it is set to double by 2020.

As the U.S. Navy lays out its strategy and future force structure, which is supported by numerous studies and war games, it views the stealth, survivability, and warfighting dominance of its undersea capabilities as providing a significant advantage. The long standing U.S. supremacy in undersea warfare has become increasingly challenged over time, however, as other nations field increasingly more robust and

cost-effective platforms in growing numbers. To supplement limited submarine platform quantities, the U.S. Navy is looking to employ more unmanned systems to extend the sensor range of the submarine and act as force multipliers.

To date, military use of UUVs has largely been driven by Explosive Ordnance Disposal (EOD) requirements. They are used to perform the dull, dirty, or dangerous tasks that take the Sailor out of the minefield. They are launched from, recovered by, and often maintained on surface support craft that chaperone these vehicles by maintaining reasonably close stand-off ranges for missions that typically last from 8 to 24 hours. As the Submarine Force looks to operationally employ UUVs going forward, these same EOD mission durations and concepts of operations are not aligned to the submarine mission requirement. The submarine has vastly superior sensing capabilities and situational awareness compared to the UUV, not to mention decision making capability. Submarines need UUVs to go beyond their sensor coverage range and

operate for some period of time (depending on the mission) without requiring the submarine to constantly provide care and direction. This allows the submarine to focus on higher priority missions versus shepherding one or more deployed UUVs. Unless the vehicle can operate on its own for a period of days to weeks, it offers limited operational utility to the submarine. This is what has driven the U.S. Navy to look to larger, more capable and costlier UUV platforms that can store enough energy to operate for these longer periods. As with all military systems, though, as price increases, quantities decrease, and there is a quality in quantity.

As a new market entrant, Riptide set out to develop a small, capable UUV platform that could be fielded affordably in high quantities. To accomplish this, it aligned to a standard A-sized sonobuoy form factor (4.88" diameter) and targeted a vehicle price on par with expendable, single-use systems like sonobuoys and Expendable Mobile ASW Training Targets (EMATTs). It sought to drive cost down while increasing flexibility through modularity in both

hardware and software. As demonstrated by its initial pre-production deliveries, Riptide was able to produce a 300m-rated UUV via highly flexible 3D printing fabrication techniques. The vehicles built to date have both free-flooded or dry payload volumes. They have been configured with single and dual frequency sonars, 360 degree cameras, and acoustic modems with more configurations in production. The standard vehicle is approximately 40 inches long and weighs about 22 lbs. It is powered by 144 alkaline AA batteries for their reasonably good energy density (on par with rechargeable lithium), worldwide availability, and unrestricted safety and shipping regulations (unlike lithium). With the high emphasis Riptide put into the hydrodynamic and electrical efficiency of the vehicle, this enables most payloads to run for 24 to 48 hours, depending on payload power and vehicle speed.

How does that achieve the days-to-weeks requirement for the Submarine Force? For this new class of UUV, Riptide has established an exclusive partnership with Open Water Power. Open Water is in development of an aluminum seawater energy system that provides a significantly higher energy density than all known lithium battery chemistries, both rechargeable and non-rechargeable, as well as all known fuel cells. Under initial Navy certification testing, it was also found to be highly safe given that the aluminum alloy is readily

Open water Power Anode showing progression of aluminum consumption

machinable with no added safety precautions. Open Water has demonstrated multiple cell stacks operating at greater than 10X the energy density of rechargeable lithium. Riptide will commence initial trials of the Open Water energy system by May of 2017. Initial design concepts predict that the micro-UUV will be able to store approximately 5 kWh of energy, which will provide the vehicle with a range of about 1,500 nautical miles at 2.8 knots.

In 2011, then Chief of Naval Operations Adm. Gary Roughead issued a challenge to the UUV industry to deliver a 1,000 nautical mile UUV. Many developed conceptual solutions, but the cost to deliver was prohibitive. Riptide, enabled by Open Water Power, is very close to delivering that capability in a highly affordable vehicle that weighs less than 25 lbs.

But what can it do? Ultimately, the vehicle, enabled by the power system, is the transport mechanism for the sensor or payload. The mission dictates the appropriate sensor. Reasonably high powered active sensors like sonars could be fielded for a few days to a week depending on their required power levels. Lower-power oceanographic sensors such as those used on gliders, hydrophones or magnetometers are ideal for longer-duration missions lasting up to a month. With an 8 to 10 knot speed capability, short-duration rapid expendable neutralization missions are also an option. In the past 18 months since starting out, Riptide has seen keen interest from various sensor providers for new, lower-cost, smaller variants of their standard sensor products. As quantities increase, greater savings are also realized, but it is important to note that secondary benefits exist as more systems are fielded, such as improved reliability and improved performance.

So, where is it going? In the U.S. Navy as well as in the global market, the demands for unmanned undersea systems are increasing. As with most operational needs, no platform is ideal for every scenario. Each platform offers advantages and disadvantages that need to be factored into their selection. With cost tending to be a major consideration, it is foreseen that there will be several XLDUUVs, potentially tens of LDUUVs, hundreds of Medium Displacement UUVs (MDUUVs), and possibly thousands of micro-UUVs. Each will offer its own unique set of capabilities for the future fleet.

Jeffrey M. Smith is the President of Riptide Autonomous Solutions. He has spent his 23-year plus career supporting the U.S. Navy and the Submarine Force.

Photo by Naval Surface Warfare Center Panama

Pictured from left to right: Riptide Autonomous Solutions Principal Software Engineer Dani Goldberg, NSWC PCD Operator of Unmanned Systems Technology Ana Zeigler, NUWC Keyport UUV Project Lead Steven Figueroa, SPAWAR Engineer Anthony Jones.

By Priya Hicks Program Lead, Electric Boat Independent Research and Development

Driving R&D Success in a Complex Engineering Environment

Measuring success in innovation is hard. Pairing this difficult task with innovating in an undersea domain that is a dynamic system-of-systems environment, which includes submarines, which are their own complex engineering challenge, creates a thought-provoking job for any program manager. At Electric Boat, the complexity of the product and inherent uncertainty of exploring new technologies and methods requires constant vigilance on the innovation front. One component of the innovation engine at Electric Boat is Independent Research and Development (IR&D), a cornerstone of the company's R&D efforts for decades.

IR&D is a source of potential solutions for the technology challenges faced by the Department of Defense (DoD). IR&D costs are allowable as indirect expenses, and companies have the independence to decide which technologies to pursue as long as the efforts are of potential interest to the DoD. IR&D does not include work that is part of a federal contract, so any technical data rights remain with the company. Selecting IR&D projects is the sole responsibility of the company conducting the IR&D work. To increase the chances for transition, however, it is important for companies to keep their DoD customers aware of promising technologies and integration efforts.

At Electric Boat, the IR&D portfolio is set up to integrate new capabilities into the way the product operates through designing the best platform and the way the product is built. Building an IR&D portfolio starts with developing an internal Request for Proposal (RFP) that takes into consideration the goals from the company's strategic plan, technology development needs from Electric Boat's concept development group and from lessons learned from our larger submarine development programs, and customer needs and perspectives from the Navy's strategic science and technology documents. The RFP is then released to the entire company for project ideas that not only are aimed at delivering
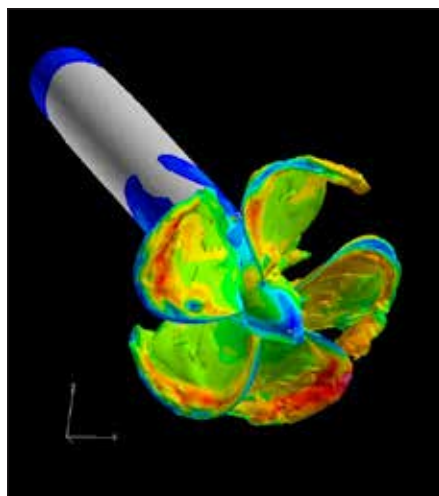

Figure 2. Example Crashback Result

value to the company and the customer but take affordability and the end user into mind.

This article will showcase three different submarine-related IR&D successes at Electric Boat.

Propeller Crashback Simulation

In 2007, computational fluid dynamics engineers at Electric Boat achieved a milestone in the simulation of propeller crashback. Propeller crashback is the sudden reversal of rotation by marine propellers, usually performed under emergency conditions. This maneuver creates large-scale unsteady flow structures when the propeller operates in the

reverse direction, generating large side loads that result in high peak blade stresses and impact the maneuvering performance of the vehicle. Using computational methods to predict these types of forces was limited in the past due to the substantial computational resources required for accurate crashback flow simulations. The engineers were able to capitalize on the supercomputing power at the Naval Oceanographic Office Major Shared Resource Center (NAVO MSRC) in conjunction with Electric Boat's IR&D-funded computational fluid dynamics (CFD) solver.[1] The engineers were able to accurately resolve the ultra-low-frequency propeller side force generated during crashbacks using a zonal variant of the Detached Eddy Simulation (DES) turbulence model.[2]

This was a milestone because the side forces generated during crashback were not well understood at the time and have significant implications in propeller design and marine vehicle maneuvering. The methodology was not only a breakthrough for propeller analysis but can also be applied to pumps, complex internal fluid flows, and control-surface design. The engineers were able to use this method to assess the main feed pump on USS *Virginia* (SSN 774) and also in the design of the Ohio Replacement control surfaces. At large angles of attack, control surfaces can have large separated flow structures, much like the structures examined in the crashback study. The methodology developed for the crashback scenario applies to this type of problem and ensures that simulations are as close as possible to real-world conditions. This is essential to ensure that design margin can be safely eliminated from designs in order to still produce and deliver an affordable, safe product.

Large Aperture Bow Array

A second successful example, which highlights a technology that was integrated into the platform, is the development and integration of the Large Aperture Bow (LAB) array on *Virginia*-class Block III. The LAB

array change accounted for $11 million of the $200 million cost savings goal for the *Virginia*-class design. This bow redesign was not only the number one technology-based cost saver leading to a $2 billion *Virginia*-class, but it also opened up the front end to enable the insertion of large flexible payload tubes. The array concept was initiated under IR&D in 2003 and 2004.

Engineers at Electric Boat worked through various concepts to eliminate different space-consuming features from legacy bow arrays to create an array that returned more arrangeable volume to the submarine but also to develop a more capable array. Using their initial IR&D work as a springboard for discussions with the Navy, the concept was so compelling it was rapidly transitioned to contract R&D in 2005. The contracted R&D funding allowed further development of the concept and in-water testing of the concept. Hundreds of SUBSAFE penetrations were eliminated as part of the design, and life-of-the-hull transducers were integrated into the design. This technology was first delivered on USS *North Dakota* (SSN 784) in 2014.[3]

Fly-by-wire Ship Control Stations

In a third example, IR&D funding was used at Electric Boat to initiate innovation

that was then carried down through different submarine programs. This effort started with IR&D in the 1980s when Electric Boat was investing in advanced fly-by-wire ship control stations. Over the course of 10 years, Electric Boat invested approximately $3 million on research and technology integration for future ship control stations. This work under IR&D was the initial steps for the first *Virginia*-class fly-by-wire ship control station. The work done for the *Virginia*-class was leveraged for the Ohio Replacement ship contol station.

The fly-by-wire transition enabled integrated fault detection and isolation during operation. To keep innovation moving for future ship control stations, Electric Boat is currently funding efforts to integrate next-generation automation into ship control and also take advantage of advances in human systems integration to create a more user friendly environment for future Submariners.

To turn vision into reality, Electric Boat is partnering with industry and academia to ensure that future ship control stations benefit from the best, most affordable technology solutions.

It is important to not be complacent with the successes that have already come to fruition. At Electric Boat, we are aiming

Figure 5. Early Ship Control Concept

to understand all of the customers' needs today and tomorrow to align our IR&D portfolio investments to provide the best product. The Navy strategic documents that are available through the Defense Innovation Marketplace, including the Navy Science and Technology Strategic Plan and Undersea Warfare Science and Technology objectives, provide invaluable insight during portfolio development. Two annual crowdsourcing events with our entire workforce and also our summer interns keep the innovative ideas flowing to feed the IR&D program. Going forward, capitalizing on the talent and passion of our young workforce paired with mentoring from our top-tier experienced engineers will help de-risk the R&D of advanced technologies. There are many more examples of success in IR&D at Electric Boat and numerous examples of success in failure. IR&D is not the place to "play it safe" but to shake out and verify new ideas for the fleet. Success is achieved through partnerships with technology providers, academia, and the labs, and these partnerships play a crucial part in developing more success stories.

References

1 Slimon, Scot A. and Craig Wagner. "Crashback Maneuvers." NAVO MSRC Navigator, Spring 2007, pages 5-7.

2 Slimon, S.A., "Computation of Internal Separated Flows Using a Zonal Detached Eddy Simulation Approach," Proceedings of International Mechanical Engineering Congress and Exposition (IMECE), 2003 American Society of Mechanical Engineers (ASME) International Engineering Congress and Exposition, Washington, D.C.

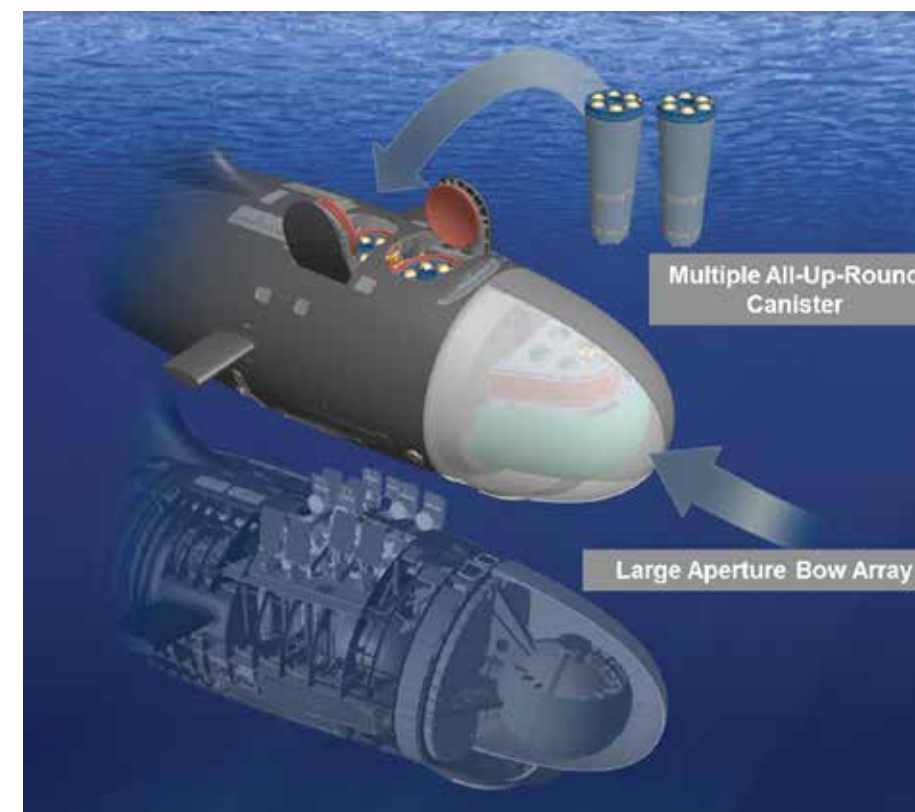3 "VIRGINIA Block III: The Revised Bow." Defense Industry Daily, 21 December 2008, http://www.defenseindustrydaily.com/virginia-block-iii-the-revised-bow-04159/.

Figure 4. Virginia Block III Bow Redesign

Multiple All-Up-Round Canister

Large Aperture Bow Array

by Dr. Vittorio Ricci, Chief Technology Officer, NUWC Newport

ANTX Lowers Barriers to the Undersea Domain

OceanAero's Submaran Wave Glider is prepared for in-water exercise.

Photo by Jori Platt, NUWC

Riptide's man-portable UUV being tested.

Photo by David Stoehr Ctr ICI Services

In August 2016, the Naval Undersea Warfare Center (NUWC) Division Newport hosted the second Annual Naval Technology Exercise (ANTX) at its Narragansett Bay Test Facility in Newport, RI. With the theme of "Cross Domain Communications and Command and Control," more than 30 participants demonstrated complementary technologies that showed the benefits of managing and controlling operations across the air, sea, and sub-sea domains.

Photo by Susan A Farley, CTR NUWC NWPT

ANTX provided an opportunity for warfare centers, industry, and academia to demonstrate in-water technologies and collaboratively help them evolve before their introduction to the fleet. One of the many goals of the event was to accelerate the technology development cycle from concept to in-water testing through rapid prototyping and fleet insertion.

Known for its intellectual capital in the undersea warfare domain, NUWC Newport is an important hub for undersea activity. It is a key conduit across the development spectrum—from science and technology to fleet support. ANTX is the venue that helps NUWC Newport connect its research and development (R&D) partners to the needs of the acquisition and warfighting community.

Dr. John Burrow, Deputy Assistant Secretary of the Navy for Research, Development, Testing and Evaluation, kicked off the event and in his keynote address said, "Rapid prototype experimentation and demonstration will change the way we do business." Dr. Burrow also highlighted the presence of senior Navy leadership to drive the evaluation of products for the warfighter as an important aspect of ANTX. He noted the importance of improving the current acquisition process of getting technology to the fleet.

"The acquisition process must be fast in order to have the operational advantage and technological superiority. This would give the Navy the capability to marry mature technol-ogy with existing needs," said Burrow. "From an acquisition perspective, the Navy wants affordable solutions from a competitive environment. Industry participation must not be dominated by one party."

Success stories

The promise of ANTX to provide a venue to demonstrate new technologies and new concepts was indeed realized. Following the 2016 event, both participants and attendees saw a variety of benefits.

Doug Prince, Lockheed Martin business development, unmanned underwater vehicles, said, "This is the first time that three autonomous vehicles in three differ-

Congressional visit on final day of ANTX 2016

Photo by Richard S. Allen, NUWC

ent domains [air, surface, and underwater] have worked together to execute a mission. This was a significant milestone."

Another large player, Northrop Grumman, demonstrated cross-domain collaboration of unmanned underwater vehicles (UUVs), unmanned surface vehicles (USVs), and unmanned aerial vehicles (UAVs) to conduct an anti-submarine warfare (ASW) mission with autonomous detection, track, classification, and engagement. Northrop Grumman also successfully adapted commercial-off-the-shelf unmanned maritime systems to accomplish an ASW mission in a challenging shallow-water environment.

A smaller company, Digital Design and Imaging Service (DDIS), demonstrated a tethered surveillance aerostat balloon equipped with an ultra-high-resolution, nine-eye camera cluster. Through ANTX introductions, DDIS was able to find Navy programs and commercial partners to refine their maritime aerostat capabilities to support over-the-horizon communication relays to surfacing unmanned submarines.

Engineer David MacCulloch from L-3 displayed his underwater energy harvesting technology at ANTX in an effort to share his work with a targeted audience.

"This was one of the most relevant shows we've been to," said MacCulloch. "We have been able to talk to decision-makers as well as engineers who have been asking probing questions."

After touring the displays and connecting

The Marlin UUV in action during ANTX Media Day.

with warfare center and industry personnel, Capt. William Guarini, Program Executive Office Littoral Combat Ship (PEO LCS), said, "ANTX provided an impressive forum for industry, warfare centers, and university participants to display and demonstrate leading-edge technologies relevant to autonomous systems. As a program manager, I was able to discuss and better understand broad R&D efforts with significant future potential throughout our Navy."

Biggest takeaways from 2016

- Hosting an unclassified event allowed non-traditional participants—firms not typically involved in defense products—to demonstrate their technologies' potential for meeting a defined Navy need. ANTX cast its net to a wider audience in an effort to bring innovation to the fleet faster.

- Collaboration was forged in an unclassified setting, with interested parties seeking each other out both before the selection to participate in the solicitation response process and while crafting their solution. After being selected for ANTX, participants were able to develop their technology solutions with other interested parties.

- Various stages of technology development were exercised—from hardware that was already in the acquisition process (MK18 Mod 2 Increment 2 UUV system, or cross-domain unmanned systems (UxVs) Command and Control with AN/BYG-1

Submarine Combat System) to technology that was being tested for the first time in-water (micro-UUVs launched from 21" UUV, or magneto-inductive communications with a UUV).

- The low-risk, inclusive, collaborative event allowed participants to take risks and stretch goals to exercise their technologies. Pushing new technologies and new concepts to their limits, or even to failure, is a learning experience for our participants to share across the R&D community supporting the CNO's goals in high-velocity learning.

With all the successes of the ANTX 2016 event, it is worth reminding ourselves of all the hard work and resources necessary to pull off an event like this. The participants should be commended for commitment to demonstrating technical excellence. Hence, it becomes ever more important to build on a strong foundation for future events, and also to continue to build and strengthen relationships across the R&D community. The real success of the event will be realized years from now as ANTX and events like it facilitate a culture change in naval acquisition, leading to rapid fielding of developing technologies and increased collaboration among technology centers.

Fostering collaboration

Industry partners continue to seek greater engagement in the acquisition process. For industry to work closely with the Navy, the current state is to bid on a proposal or form a partnership through a Cooperative Research and Development Agreement. Due to limited resources, these methods may exclude some potential partners. ANTX solves this by providing an open forum to get in front of stakeholders and demonstrate technology. This collaboration will lead to better products that meet the warfighters' needs sooner.

Traditional engagement includes meetings, which can often be a one-way communication. At ANTX, engineers and scientists can gather to develop better insights that are shared—both sides benefit and evolve. The in-person experience helps developers of technology better understand the need to morph their products and socialize their

Lockheed Martin employed the Marlin UUV as part of their cross-domain communications exercise.

Riggers prepare a UUV for in-water testing.

products with decision makers.

One of the challenges industry and academia face when developing undersea technologies is that it can be difficult to navigate through all the bureaucracy involved in trying to work with the government. While most technologies take a long time to develop, a partnership can yield new capabilities and new designs faster with the greater potential for breakthroughs. This is a vital piece of the acquisition puzzle as the Navy remains heavily invested in pushing the envelope of its own capabilities and doing so at a rapid pace.

Culture change

In addition to the partnerships, the essential professional networking, and the vast workforce development opportunities provided by ANTX, an underlying message of the event is culture change. Persuading decision-makers within the warfare center enterprise, industry, and academia to view technology development as a multi-entity sandbox is the shift in culture needed for the rapid advancement of warfighter capabilities. The ability to collaborate and innovate must be made easier for people in all communities and at all levels.

Participating in events such as ANTX and experiencing positive results—both tangible and intangible—can facilitate a change in behavior by all involved on both sides of the acquisition process so collaboration and innovation are happening not just at ANTX but all the time. The desired future state is that collaboration and innovation is the norm across the

Naval research and development establishment and defense industry.

Following the success of ANTX 2016, the Marine Corps will conduct a similar exercise in April 2017 at Camp Pendleton. ANTX 2017, August 14-18, will connect NUWC Newport to Naval Surface Warfare Center Panama City and NUWC Keyport.

The ultimate goal from a warfare center perspective is for industry—including businesses both large and small—to partner with the Navy's technical departments and test their technologies in the Navy's unique labs and ranges. Improving the Navy's undersea test and evaluation infrastructure and adding new capabilities are priorities that will yield two significant benefits. First, it accelerates the development and test cycle so that we are learning faster and more quickly fielding relevant products for the warfighters. Second, as it is expensive to test undersea technology, maintaining easily accessible test infrastructure lowers the barrier to entry, particularly for small business, into the undersea domain.

Government and industry should be leveraging their efforts. By sharing what they are doing, they can share costs and evolve faster. ANTX provides its participants with greater insights to the capabilities that the warfighter needs as well as breakthrough capabilities they did not know were possible.

The end result is that industry prospers and the warfighters get what they need… sooner!

The Mk 18 Mod 2 Increment 2 was part of testing for NUWC Newport and multiple partners.

by Lt. Tia Nichole McMillen, Submarine Force Pacific Public Affairs

iLab Opening Boosts Submarine Innovation

Photo by Petty Officer 2nd Class Michael H. Lee

Rear Adm. Frederick "Fritz" J. Roegge, Commander, Submarine Force, U.S. Pacific Fleet (CSP), joined industry partners to cut the ribbon officially opening the CSP Innovation Lab (iLab) on Nov. 7, 2016.

The CSP iLab is an unclassified space created to allow Submariners to prototype virtual reality (VR) and augmented reality (AR) technologies to generate ideas for low-cost solutions to fleet training and operational challenges. Squadron commodores and unit commanding officers are highly encouraged to send their Submariners to the CSP iLab to:

See cutting-edge VR/AR technologies

Share ideas for using VR/AR aboard submarines

Shape the future of submarine training, operations, and **maintenance**

The iLab's mission is to exploit and leverage commercial sector research and tools from the computer gaming industry and cellular phone markets to explore the latest technologies.

"This emerging maker-space is where Submariners can prototype low-cost solutions to training and operational problems using cutting-edge virtual reality and augmented reality tools," said Roegge. "To achieve high-velocity learning, we must expand the use of learning-centered technologies and put them in the hands of our greatest asset: our Sailors. Our Sailors are the ones closest to the problems and therefore the ones best positioned to come up with innovative ideas for their solutions."

The CSP iLab supports the Commander Pacific Fleet (CPF) Bridge initiative, the Chief of Naval Operations' "High Velocity Learning," and the Secretary of the Navy's "Innovation Vision Elements." The iLab is outfitted and operated in partnership with the Space and Naval Warfare Systems Command (SPAWAR), Battlefield Exploitation of Mixed Reality (BEMR) Lab, and the Naval Sea Systems Command (NAVSEA) New Training Technologies Program Office.

"The capabilities of the Navy need to consistently move forward," said Chief Petty Officer Craig McHenry, Naval Submarine Training Center Pacific facilities manager. "There is so much knowledge out there that we must understand and use to our tactical and operational advantage. The iLab is a tool our Sailors can use to unlock that ability and capitalize on our findings."

Rear Adm. Roegge has also established a relationship with the University of Hawaii's Applied Research Laboratory (ARL) and the Laboratory for Advanced Visualization and Applications (LAVA). These and other key partners will add new demonstrations and assist Submariners in building tailored applications based on the ideas received.

"The command is embracing the capabilities of the future

and attempting to use these capabilities to its advantage," said McHenry. "High-velocity learning, as exemplified by our iLab, can only make our military and civilian team stronger and smarter. I'm proud to serve on this team, and I'm excited to see where we take this technology in the future."

The iLab needs Submariners of all ranks and career fields to observe the technologies and generate ideas for their use. Ideas, both bold and modest, will be captured via log books or email. An iLab Idea Board will review the proposals for further development. The goal of the iLab is to rapidly transition cutting-edge technology ideas, generated by the Submariner, to the waterfront.

"The iLab is a breakthrough initiative to present transformative tools to the Submarine Force and gather input to rapidly improve shipboard learning technologies," said Capt. Erik Burian, COMSUBPAC director for training, doctrine, and tactical development.

Current iLab Capabilities

OceanLens. OceanLens is like Google Earth for the undersea environment, viewed via an Oculus Rift Virtual Reality headset. It includes a 3D immersive environment for visualizing undersea topography (bathymetric data). Some ideas for use include drive-through or swim-through waterspace visualization with bathymetric features, assigned waterspace for ships, adjacent waterspace assigned to other submarines, and stay out/warning areas. Higher resolution bathymetric data could be used for planning and rehearsal of near or on-shore missions.

zSpace 3D Maintenance. zSpace allows Sailors to interact with a 3D display using stereoscopic glasses and a special pen. Sailors can easily practice virtual maintenance activities on any modeled equipment. The glasses have head tracking, which allows Sailors to view equipment from all sides. They can virtually disassemble and reassemble equipment, shift to an exploded view of all sub-components, and make equipment housing transparent so that they can easily view interior parts. Also available in the iLab is an iPad-based demonstration of a 3D-printed Woodward Governor diesel control. The interactive training virtualizes the operations, maintenance procedures, and instructional videos required to install, remove, and start-up a diesel generator using a Woodward Governor.

Eagle 360 Piloting Brief. The Eagle 360 capability uses a 3D-printed mount with seven GoPro cameras to capture a 360-degree video of every submarine route into and out of Pearl Harbor. Eagle 360 includes a drive-through view of actual Pearl Harbor port entry conditions, close-up views of navigation aids, buoys, and natural features along with a reduced visibility/night simulation. The goal is to establish a library of piloting briefs for every submarine port. When this library is aboard every submarine, it will allow a piloting party and bridge party to essentially make the port entry prior to actually going there. Submarine crews will be able to gain experience, improve safety, and reduce risks caused by unfamiliarity or confusion at new ports.

HoloLens 3D Immersive Walk-Through. Using the Microsoft HoloLens Augmented Reality headset, Sailors can virtually experience how to move within and through a holographic model floating in the iLab. Holograms can include any object from the real world, ranging from running engines, commercial aircraft, or military sub-

marines. These holograms allow the Sailor to experience being there without physically being there. Some uses include training for new crewmembers at submarine school to shorten the time to become familiar with the layout of their new submarine, training firefighters who may not have regular access to all compartments in a submarine, and visualizing maintenance issues such as interference removal for planning. The submarine's officer of the deck could use the HoloLens and OceanLens together to "see through" the hull of the submarine for more intuitive situational awareness of the increasingly complex undersea environment, including contacts, bottom topography, wave propagation, contacts, and unmanned systems. The HoloLens has Skype capability so that a distant expert can see through the eyes of the Sailors and coach them through maintenance, operations, or inspections in real time. For example, several Sailors put together a physical valve/galvanized pipe assembly in the iLab by getting coaching from a remote expert via Skype on HoloLens. Hands-free on-demand support can both improve the response time to Sailors that need assistance and lighten the burden on technical representatives by reducing airline flights, cost, time, and fatigue from traveling.

360 Video Capture/Replay. Sailors can leverage 360-degree video for immersive capture of submarine training and maintenance events. They can easily record "what right looks like" and then share best practices with other Sailors. Recent technologies available in the iLab allow rapid transfer of 360-degree video to a commercial smart phone or headset using a simple app. No special stitching is needed before Sailors can review the event as if they were there. Recently, a Sailor used the iLab's Samsung Gear360 video camera to capture short events and then made them available for viewing on a smart phone or headset in about five minutes.

Ideas can always be submitted to CSPiLab@navy.mil or CSPiLab@navy.smil.mil. There will be quarterly iLab Idea Boards conducted at CSP beginning in December. The top ideas that emerge will be prioritized by CSP leadership and pushed forward.

For more news from the Pacific Submarine Force, visit www.csp.navy.mil.

Photo by Petty Officer 2nd Class Michael H. Lee

Rear Adm. Fritz Roegge participates in an augmented-reality demonstration at the official opening of the COMSUBPAC Innovation Lab (iLab).

Joining the Fleet

USS *Washington* (SSN 787)

USS *Washington* is completing construction at Huntington Ingalls Industries Newport News Shipbuilding in Newport News, Va., and is scheduled to join the fleet in 2017. She is the 14th *Virginia*-class submarine. Her Pre-Commissioning Unit (PCU) crew began manning up in January 2014 to support the extensive testing, qualifications, and preparations required to bring a nuclear submarine to life. When delivered, *Washington* will be the most technologically advanced submarine in service; her design incorporates significant innovations to reduce acquisition costs over earlier boats of the class without impacting mission capabilities.

Boat's sponsor: **Elisabeth Mabus**
Commanding Officer: **Capt. Jason Schneider**
Executive Officer: **Lt. Cmdr. Brian M. Rhoades**
Chief of the Boat: **ITSCM (SS) Adam Burchette**

USS *Colorado* (PCU 788)

USS *Colorado* (PCU 788) is the 15th *Virginia*-class fast-attack submarine and the fifth *Virginia*-class Block III submarine. *Virginia* submarines are constructed in a joint partnership between General Dynamics Electric Boat and Huntington Ingalls Industries Newport News Shipbuilding. The boat began construction in March of 2012 and is tracking to a late 2017 commissioning. *Colorado* is currently completing her construction at the Electric Boat shipyard in Groton, Conn.

Boat's sponsor: **Anne Mabus**
Commanding Officer: **Cmdr. Ken Franklin**
Executive Officer: **Lt. Cmdr. Stephen Col**
Chief of the Boat: **ETCM (SS) Freddie Richter**

USS *Indiana* (PCU 789)

USS Indiana (PCU 789) is the 16th *Virginia*-class fast-attack submarine and the sixth *Virginia*-class Block III submarine. The boat began construction in September of 2012 and will be christened on April 29, 2017 when the boat's sponsor, Mrs. Diane Donald, breaks a bottle of champagne on the bow.

Boat's sponsor: **Diane Donald**
Commanding Officer: **Cmdr. Zimbauer**
Executive Officer: **Lt. Cmdr. Heineman**
Chief of the Boat: **Master Chief Herring**

Leaving the Fleet

USS *Albuquerque* (SSN 706)

After 33 years of service, the *Los Angeles*-class submarine USS *Albuquerque* was decommissioned February 27 at Keyport Undersea Museum.

The keel was laid by the Electric Boat Division of General Dynamics in 1979, and she was launched March 13, 1982. *Albuquerque* was commissioned on May 21, 1983, at Naval Base New London, and deployed 21 times to every corner of the globe, accumulating approximately 1.1 million nautical miles steamed, the equivalent of 52 global circumnavigations. She performed 1,075 dives, made port calls in over 35 foreign ports, participated in over 18 major international naval exercises, and had 14 commanding officers. The boat earned three Navy Unit Commendations, four Meritorious Unit Commendations, and four Battle Efficiency "E" Awards.

USS *Dallas* (SSN 700)

The star of "The Hunt for Red October" returned from its final overseas deployment last November and, after 33 years in the fleet, will be inactivated.

As one of 42 *Los Angeles*-class submarines remaining in the fleet, it was the first attack submarine to carry a dry-deck shelter, which housed a vehicle for launching and recovering special operations forces. *Dallas* was commissioned July 18, 1981 as the seventh member in a class of 61 submarines.

Dallas was initially attached to Submarine Development Squadron 12 in New London, Conn., and was used for research and development projects. She had one Indian Ocean, three Mediterranean, seven North Atlantic deployments, and circumnavigated the globe. She also participated in Operations Desert Shield/Storm in the 1990s.

The Navy postponed the decommissioning of *Dallas* to 2017 from her earlier scheduled retirement in 2015, a decision that saved $10m in pre-inactivation restricted availability (PIRA) costs and enabled the Navy to focus on mission requirements and balance workload and workforce needs across the force.

USS *Buffalo* (SSN 715)

Over her more than 30 years, USS *Buffalo* conducted 11 deployments. As diplomats of the United States, the submarine's crew participated in port calls in Australia, the Philippines, the Republic of Korea (ROK), Saipan, Japan, Singapore, and Thailand.

Buffalo participated in eight multinational exercises working with Japan, Australia, ROK, and Thailand to include Operation Valiant Shield, undersea warfare exercises, security exercises, and Cooperation Afloat Operation and Training exercises.

Buffalo is a *Los Angeles*-class submarine and was built by Newport News Shipbuilding & Drydock, launched in 1982, and commissioned in November 1983. On several occasions, she was recognized as the best submarine in Submarine Squadron 15 for Battle Efficiency. *Buffalo* was the 2011 Pacific Fleet Arleigh Burke Fleet Trophy Award recipient for superior performance and improved battle efficiency.

USS *San Francisco* (SSN 711)

The contract to build USS *San Francisco* was awarded to Newport News Shipbuilding and Dry Dock Co. in 1975, and her keel was laid down in 1977. She was launched on October 27, 1979, and commissioned on April 24, 1981.

Following an initial shakedown cruise, *San Francisco* joined Submarine Force, U.S. Pacific Fleet and moved to her homeport at Pearl Harbor. *San Francisco* completed deployments in 1982, 1983, 1985, and 1986 with the U.S. Seventh Fleet and various independent operations in the Pacific in 1986 earning the Battle Efficiency "E" for Submarine Squadron Seven in 1985. She earned a Navy Unit Commendation, a second Battle Efficiency "E" for Submarine Squadron Seven, and her crew was awarded the Navy Expeditionary Medal for independent operations in 1988.

In 1994 the submarine was awarded the Commander Submarine Squadron Seven "T" for excellence in tactical operations and a Meritorious Unit Commendation for the 1994 Western Pacific deployment.

SUBASE New London Opens Navy's First NOFFS Zone

A ribbon cutting ceremony was held for the Navy's first Navy Operational Fitness and Fueling System (NOFFS) Zone at Morton Hall Gymnasium on Naval Submarine Base New London (SUBASE), Jan 12 which features an indoor turf area, battle ropes, tire flipping, weight lifting, box jumping, and other movement based activities.

Originally designed for Sailors to continually be physically active while not having access to a fitness facility or equipment, NOFFS has been undergoing a rebranding since 2014, and aims to instruct Sailors how to physically train effectively and safely, and make healthy nutritional choices in both shore and operational environments.

"NOFFS mimics the same type of motions done on the waterfront like pushing, pulling, and lifting," said Capt. Paul Whitescarver, commanding officer of SUBASE. "We want to prevent injuries in the future, and it's pretty awesome for SUBASE New London to open the first NOFFS Zone."

The original NOFFS Operational program released in 2009 provided Sailors with resistance bands that could easily be taken out to sea, or at home, requiring minimal space.

"Many people associate NOFFS with a bag of rubber bands, but we wanted to give people another look at what NOFFS really is, an entire system including the facility, nutrition and cell phone application where you can still have the virtual trainer if an MWR Fitness trainer isn't available in person," said Tunde Ridley, Morale, Welfare and Recreation (MWR) section head of Navy Fitness. "The program focuses on resiliency and eliminating musculoskeletal injuries, and provides a program where Sailors or anyone who wanted to use it didn't have to think about it. We eliminate the guesswork."

Ridley also said there are four different NOFFS series available, Operational, Strength, Endurance and Sandbag that combined with the cell-phone application, makes NOFFS easily portable to train with from home, deployed, or in a fitness facility.

MWR trainers at Morton Hall will be hosting classes seven times a week, and the NOFFS Zone is available for individual and command use. For more information, please call MWR at (860) 694-2298.

Additional pilot NOFFS Zones opening in the future include Naval Base Kitsap-Bangor, Naval Base Ventura County, Naval Station Norfolk, and Naval Air Station Pensacola.

The NOFFS application is available for both Android and iOS, and can be found at www.navyfitness.org

SailorsFirst

New Navy Ratings

The Navy announced the establishment of four new ratings for active duty Sailors, yeoman submarine (YNS), logistics specialist submarine (LSS), culinary specialist submarine (CSS) and fire controlman Aegis (FCA) in NAVADMIN 021/17.

This realignment was made to improve management of ship manning and personnel inventory for both the Surface and Submarine ratings.

The new ratings will be effective:

- Sept. 2, 2017, for E-6
- Oct. 17, 2017, for E-7 through E-9
- Nov. 28, 2017, for E-1 through E-5

Sailors serving as Aegis fire controlman and yeoman, logistics specialist, culinary specialist submarine Sailors will be converted to their applicable service ratings by enlisted community managers with no action needed from the member.

More information can be found at www.npc.navy.mil.

New App for Blended Retirement Choices

A new application for mobile devices designed to enhance financial literacy for Sailors is now available that will help provide the latest info on the Blended Retirement System (BRS) that goes into effect in 2018.

Targeted primarily for active duty and reserve service members, the app also serves as a valuable tool for Navy family members. Users will be able to explore issues like managing their credit, building a spending plan, home buying, moving, as well as how to navigate survivor benefits, insurance and the Thrift Savings Plan (TSP) among many other topics.

Outside of the standard financial topics, there is a BRS resources tab that includes infographics, frequently asked questions, as well as training links that will be refreshed as new courses and training materials become available. Once finished, the retirement calculator for BRS will be included as part of the app as well.

Service members eligible to opt-into BRS will have until the end of 2018 to decide if they want to switch to the new plan. Everyone serving today can stay under the current system, while those with fewer than 12 years of service as of the end of 2017 will have an opportunity to opt-into the new retirement system. New Sailors will automatically be enrolled into the new system as of the start of 2018.

The Navy Financial Literacy mobile application is available for download from the iTunes and Google Play online stores. To find the free app, search "Navy Financial Literacy" in the app stores or in your Web browser.

Welcome Home!

Petty Officer 1st Class Jonathan Atkins is greeted with the first kiss by his wife Jennifer during a homecoming celebration for *Los Angeles*-class attack submarine USS *Oklahoma City* (SSN 723). *Oklahoma City*, one of four forward-deployed submarines homeported in Apra Harbor, returned to Guam after an eight-month maintenance period known as Docking.

Photo by Petty Officer 1st Class Jamica Johnson

SailorsFirst

Improved Flame Resistant Variant Coverall Approved

Commander, U.S. Fleet Forces (USFF) announced the authorization of the Improved Flame Resistant Variant (IFRV) coverall as an approved fleet organizational clothing item.

The approval came after a review of the results from recently completed afloat wear tests conducted aboard three deploying ships and involving more than 700 Sailors. The IFRV coveralls are intended to replace the Flame Resistant Variant (FRV) coveralls currently in use throughout the fleet.

The original FRVs were introduced in response to widespread reports in which Sailors afloat were at risk because most of their required uniforms were not flame resistant. The new IFRV coverall is made from a flame resistant, tri-fiber blend. It weighs significantly less than the current FRV fabrics and provides improved moisture management by allowing the fiber to breathe more efficiently. This IFRV coverall also offers arc flash protection, a notable upgrade in safety from the current FRV. The IFRV coverall is also designed to last nearly twice as long as the FRV.

USFF conducted coverall wear tests aboard three ships, amphibious assault ship USS *Kearsarge* (LHD 3), guided-missile destroyer USS *Carney* (DDG 64), and fast-attack submarine USS *Newport News* (SSN 750) during their recent deployments. Both a flight suit and traditional version were tested, with surveys taken both mid- and post-deployment. The results were overwhelmingly positive for the IFRV and favorable toward the traditional version of the coverall.

For more information, visit http://www.navy.mil, http://www.facebook.com/usnavy, or http://www.twitter.com/usnavy.

New Navy Suicide Prevention Program

The Navy's 21st Century Sailor Office announced Feb. 6 that the suicide prevention program Sailor Assistance and Intercept for Life (SAIL) is now available Navy-wide at all Fleet and Family Support Center (FFSC) locations.

SAIL is designed to provide rapid assistance, on-going risk assessment and support for Sailors who have exhibited suicide-related behavior. It is aimed at supplementing existing mental health treatment by providing continual support through the first 90 days after suicide-related behavior.

SAIL is not designed to replace clinical treatment for any suicide related behavior. However, upon receiving information from commands about a Sailor who has demonstrated suicide-related behavior, Suicide Prevention Coordinators will work with CNIC, and in turn an FFSC case manager, whose responsibility will be to reach out to the individual Sailor to see if he or she would volunteer to participate in the SAIL program. Case managers will contact Sailors in the 90 days following suicide-related behavior.

The Military Crisis Line offers confidential support 24 hours a day, 7 days a week. Call 1-800-273-8255 and Press 1, chat online at http://www.militarycrisiline.net or send a text message to 838255.

"What is Sailor 2025? How is it going to affect me? What's in it for me?"

Sailor 2025 is the Navy's program to improve and modernize personnel management and training systems to effectively recruit, develop, manage, and retain the force of tomorrow. In a nutshell, it means giving Sailors more control and ownership over their careers!

Sailor 2025 is built on three pillars:

• A modernized personnel system

• An enriched culture

• A career continuum of learning

The Navy has already started modernizing personnel policies to give Sailors ownership over their careers. Here are some ongoing initiatives that have been recently 'revamped' and improved:

Career Intermission Program (CIP) – Some program eligibility barriers have been removed and participant quotas have been increased. CIP allows individuals to take a sabbatical from the Navy for up to three years to pursue goals of their choosing.

Fleet Scholar Education Program (FSEP) – Expanded, fully-funded, in-residence graduate degree opportunities at civilian institutions by 30 billets at the officers' (URL and IWC officer eligible) choice of institution.

Billet Based Distribution (BBD) – Expanded choice and flexibility; enables the Navy to more efficiently assign personnel in support of warfighting readiness and more accurately match Sailors' unique skillsets to specific billets.

Meritorious Advancement Program (MAP) – Provided more opportunities to Fleet COs, CMCs, and the Chief's Mess to better identify and meritoriously advance talented, hard-working Sailors at sea and ashore.

Secretary of the Navy Tours with Industry (SNTWI) – Provided opportunities for 30 top-performing Sailors at high-performing corporations to observe and learn the newest insights and best practices to bring back to the Fleet.

Navy Enlisted Rating Modernization – This is a multi-year initiative to eliminate Navy rating titles. It will ensure enhanced career flexibility where combinations of rates with similar training and experience exist. It will ultimately provide greater training and credentialing opportunities and help Sailors become more marketable to civilian employers once they leave the Service.

Visit the following website for more specific Sailor 2025 information and guidance: https://www.public.navy.mil/bupers-npc/career/talentmanagement/Pages/default2.aspx

> *UNDERSEA WARFARE* Magazine has created this section in recognition of the enlisted Submariner—but we want **you** to get involved in the success of this effort. We would like you to send us "Community Outreach," or "Liberty" photos, and/or "Homecoming" photos of families being re-united as the crews return.
> Send your submissions to the Military Editor via email to: underseawarfare@hotmail.com

Changes of Command

USS *Alaska* (SSBN 732) (G)
Cmdr. Eric Cole relieved
Cmdr. Craig Gummer

USS *Albany* (SSN 753)
Cmdr. Roy Wilson Jr. relieved
Cmdr. Robert Landis

USS *Bremerton* (SSN 698)
Cmdr. Travis Zettel relieved
Cmdr. Wes Bringham

USS *City of Corpus Christi* (SSN 705)
Cmdr. James Thorp relieved
Capt. Travis Petzoldt

USS *Dallas* (SSN 700)
Cmdr. David Kaiser relieved
Capt. Jack Houdeshell

USS *Emory S. Land* (AS 39)
Capt. Douglas Bradley relieved
Capt. Mark Prokopius

USS *Florida* (SSGN 728) (B)
Capt. Brett Moyes relieved
Capt. Nathan Martin

USS *Georgia* (SSGN 729) (G)
Capt. Douglas Jordan relieved
Capt. Michael Badorf

USS *Houston* (SSN 713)
Cmdr. Andrew Ring relieved
Cmdr. Scott McGinnis

USS *Illinois* (SSN 786)
Cmdr. Neil Steinhagen relieved
Cmdr. Jessie Porter

USS *Louisiana* (SSBN 743) (B)
Cmdr. Chimi Zacot relieved
Cmdr. Michael Daigle Jr.

USS *Newport News* (SSN 750)
Cmdr. Michael Grubb relieved
Cmdr. Patrick Clark

USS *North Carolina* (SSN 777)
Cmdr. Matthew Lewis relieved
Cmdr. Gary Montalvo Jr.

USS *Ohio* (SSGN 726) (B)
Capt. David Soldow relieved
Capt. Broderick Berkhout

USS *Oklahoma City* (SSN 723)
Cmdr. Thomas O'Donnell relieved
Cmdr. Michael Conner

USS *Pittsburgh* (SSN 720)
Cmdr. James Colston relieved
Cmdr. William Solomon

USS *Pennsylvania* (SSBN 735) (B)
Cmdr. Steven Everhart relieved
Cmdr. John Cage

USS *San Francisco* (SSN 711)
Capt. Daniel Caldwell relieved
Cmdr. Jeffrey Juergens

USS *Seawolf* (SSN 21)
Cmdr. Christopher George relieved
Capt. Jeffrey Bierley

USS *Springfield* (SSN 761)
Cmdr. Brent Spillner relieved
Capt. Roger Meyer

USS *Tennessee* (SSBN 734) (G)
Cmdr. Jon Schaffner relieved
Cmdr. Christopher Bohner

USS *Texas* (SSN 775)
Cmdr. Michael Dolbec relieved
Cmdr. Todd Nethercott

USS *Virginia* (SSN 774)
Cmdr. Jeffery Anderson relieved
Cmdr. Steven Antcliff

Qualified for Command

Lt. Christopher Abplanalp
USS *Missouri* (SSN 780)

Lt. Michael Furlan
USS *Hartford* (SSN 768)

Lt. Philip Shrader
USS *Missouri* (SSN 780)

Lt. Cmdr. Grant Wanier
USS *Hartford* (SSN 768)

Qualified in Submarines

Lt. j.g. Travis Adams
USS *Kentucky* (SSBN 737) (G)

Lt. j.g. Adam Albrecht
USS *Tucson* (SSN 770)

Naval Undersea Warfare Center (NUWC) Division Keyport held a ribbon cutting for its new Unmanned Undersea Vehicle (UUV) homeport maintenance and storage space, Barb Hall, located within NUWC Keyport's Vehicle Integration Prototyping Experimentation and Reconfiguration facility.

Representatives from many of the organizations critical to the future of UUVs—Warfare Centers, academia, industry, and warfighters—gathered at NUWC Keyport for the event. Rear Adm. Frederick J. "Fritz" Roegge, Commander, Submarine Force, U.S. Pacific Fleet, was the keynote speaker. Other speakers included Congressman Derek Kilmer, who wielded the ribbon-cutting scissors, Captain Doug LaCoste, NUWC Keyport Commanding Officer, Captain Rob Gaucher, Commander Submarine Development Squadron Five, and NUWC Newport's Dr. Brian McKeon, who gave his perspective on Barb Hall's contribution and potential to the undersea warfare community.

Lt. Peter Alexakos
USS *Dallas* (SSN 700)

Lt. j.g. Jared Anongos
USS *Nevada* (SSBN 733) (B)

Lt. j.g. Ryder Ashcraft
USS *Maine* (SSBN 741) (G)

Lt. j.g. Mark Atkins
USS *Providence* (SSN 719)

Lt. j.g. Marshall Atwood
USS *Rhode Island* (SSBN 740) (B)

Lt. j.g. William Baber
USS *Texas* (SSN 775)

Lt. j.g. Andrew Beliveau
USS *Maine* (SSBN 741) (B)

Lt. j.g. Martin Bennett
USS *Houston* (SSN 713)

Lt. j.g. Ryan Benroth
USS *Georgia* (SSGN 729) (B)

Lt. j.g. Tyler Bergman
USS *City of Corpus Christi* (SSN 705)

Lt. j.g. John Blake
USS *Tucson* (SSN 770)

Lt. j.g. Brian Bloom
USS *Pittsburgh* (SSN 720)

Lt. j.g. Herakles Boardman
USS *Dallas* (SSN 700)

Lt. j.g. William Boykin III
USS *Alabama* (SSBN 731) (G)

Lt. j.g. Charles Brand
USS *San Juan* (SSN 751)

Lt. j.g. Chase Brown
USS *Alexandria* (SSN 757)

Lt. j.g. Stephen Byrd
USS *Greeneville* (SSN 772)

Lt. j.g. Elijah Callaghan
USS *Tennessee* (SSBN 734) (B)

Lt. j.g. Nicholas Campbell
USS *Newport News* (SSN 750)

Lt. j.g. Jonadel Caro
USS *Florida* (SSGN 728) (B)

Lt. j.g. Antonio Carreno
USS *Alaska* (SSBN 732) (G)

Lt. j.g. Charles Celerier
USS *Topeka* (SSN 754)

Lt. j.g. Vincent Chandler
USS *Olympia* (SSN 717)

Lt. j.g. John Chisvette
USS *North Carolina* (SSN 777)

Lt. j.g. Vincent Cipollone
USS *Tennessee* (SSBN 734) (B)

Lt. j.g. John Claypool
USS *Charlotte* (SSN 766)

Lt. j.g. Mark Colby
USS *Pasadena* (SSN 752)

Lt. j.g. Patrick Collins
USS *New Mexico* (SSN 779)

Lt. j.g. Joseph Couillard
USS *Michigan* (SSGN 727) (G)

Lt. j.g. Chase Cummins
USS *Greeneville* (SSN 772)

Lt. j.g. Matthew Curtis
USS *Pennsylvania* (SSBN 735) (B)

Lt. j.g. Matthew Cutts
USS *Hartford* (SSN 768)

Lt. j.g. Ty Daniels
USS *Jefferson City* (SSN 759)

Lt. j.g. David Davispope
USS *Ohio* (SSGN 726) (B)

Lt. j.g. Benjamin Desch
USS *Henry M. Jackson* (SSBN 730)

Lt. j.g. Daryl Dietsche
USS *Oklahoma City* (SSN 723)

Lt. j.g. Steven Digiannurio
USS *Buffalo* (SSN 715)

Lt. j.g. Daniel Doran
USS *Georgia* (SSGN 729) (B)

Lt. j.g. Scott Ebert
USS *Columbia* (SSN 771)

Lt. j.g. Lucas Evans
USS *Bremerton* (SSN 698)

Lt. j.g. Brian Fitzgerald
USS *Cheyenne* (SSN 773)

Lt. j.g. William Fortin
USS *San Juan* (SSN 751)

Lt. j.g. Benjamin Francis
USS *Alaska* (SSBN 732)

Lt. j.g. Joseph Frank
USS *Ohio* (SSGN 726) (G)

Lt. j.g. Russell Friedl
USS *Jefferson City* (SSN 759)

Lt. j.g. Connor Gagliardi
USS *Santa Fe* (SSN 763)

Lt. j.g. Timothy Garrett
USS *Henry M. Jackson* (SSBN 730) (G)

Lt. j.g. Justin Gaspar
USS *Hartford* (SSN 768)

Lt. j.g. James Geisemann
USS *Florida* (SSGN 728) (G)

Lt. j.g. Todd Gerald
USS *Asheville* (SSN 758)

Lt. j.g. Jacob Grogan
USS *Pennsylvania* (SSBN 735) (B)

Lt. j.g. Brian Gureck
USS *Louisville* (SSN 724)

Lt. j.g. Matthew Gustafson
USS *Mississippi* (SSN 782)

Lt. j.g. Jon Hamilton
USS *Tennessee* (SSBN 734) (B)

Lt. j.g. Colter Hanson
USS *Ohio* (SSGN 726) (B)

Lt. j.g. Fridolin Heer
USS *Oklahoma* City (SSN 723)

COMSUBLANT Winners of 2016 Battle Efficiency Competition Awards:

SUBRON 4
USS *California* (SSN 781)
Cmdr. E. Sager
Lt. Cmdr. M. Thatcher
MCPO(SS) T. Kuchta

SUBRON 6
USS *Newport News* (SSN 750)
Cmdr. P. Clark (D)
Cmdr. M. Grubb (R)
Lt. Cmdr. B. Bateman (D)
Lt. Cmdr. T. Kim (R)
MCPO(SS) R. McClellan

SUBRON 12
USS *San Juan* (SSN 751)
Cmdr. J. Craddock
Lt. Cmdr. S. Charnik (D)
Lt. Cmdr. M. Lilleberg (R)
MCPO(SS) W. McLellan

SUBRON 16
USS *Florida* (SSGN 728)(B)
Capt. N. Martin
Lt. Cmdr. J. Kaper
MCPO(SS) N. Sims

USS *Florida* (SSGN 728)(G)
Capt. W. McKinney
Lt. Cmdr. L. Patterson
MCPO(SS) M. Quick (D)
MCPO(SS) R. Langley (R)

SUBRON 20
USS *Alaska* (SSBN 732)(B)
Cmdr. D. Forman
Lt. Cmdr. J. Hurt
MCPO(SS) D. Wright

USS *Alaska* (SSBN 732)(G)
Cmdr. C. Gummer (D)
Cmdr. E. Cole (R)
Lt. Cmdr. W. Dull
MCPO(SS) B. Doebler (D)
SCPO(SS) M. Barlow (R)

Lt. j.g. Jordan Hester
USS *Connecticut* (SSN 22)

Lt. j.g. Miles Hill
USS *Columbia* (SSN 771)

Lt. j.g. Colin Hilligas
USS *Santa Fe* (SSN 763)

Lt. j.g. Joseph Hussey
USS *Helena* (SSN 725)

Lt. j.g. Sarah Jaeger
USS *Wyoming* (SSBN 742) (B)

Lt. j.g. Joshua Jones
USS *Topeka* (SSN 754)

Lt. j.g. Daniel Kindervater
USS *Rhode Island* (SSBN 740) (G)

Lt. j.g. Andrew King
USS *Nevada* (SSBN 733) (B)

Lt. j.g. Alexander Kornick
USS *Pittsburgh* (SSN 720)

Lt. j.g. Ryan Krady
USS *Columbus* (SSN 762)

Lt. j.g. Jordan Kronshage
USS *Minnesota* (SSN 783)

Lt. j.g. Tyler Kuhn
USS *Montpelier* (SSN 765)

Lt. j.g. Michael Lacey
USS *Buffalo* (SSN 715)

Lt. j.g. Eric Lantz
USS *New Hampshire* (SSN 778)

Lt. j.g. John Lawler
USS *Hawaii* (SSN 776)

Lt. j.g. Victor Lee
USS *Alabama* (SSBN 731) (G)

Lt. j.g. Bradley Lentz
USS *Louisville* (SSN 724)

Lt. j.g. Maximilian Leutermann
USS *Olympia* (SSN 717)

Lt. j.g. Mark Lindle
USS *Columbus* (SSN 762)

Lt. j.g. Nicholas Linsodonnell
USS *Asheville* (SSN 758)

Lt. j.g. William Love
USS *Mississippi* (SSN 782)

Lt. j.g. Saverio Maldari
USS *North Dakota* (SSN 784)

Lt. j.g. Michael Martin
USS *Montpelier* (SSN 765)

Lt. j.g. Keegan McAllister
USS *Jimmy Carter* (SSN 23)

Lt. j.g. David McClain
USS *Michigan* (SSGN 727) (B)

Lt. j.g. Jacob McDaniel
USS *Nevada* (SSBN 733) (G)

Lt. j.g. Owen McGrath
USS *Houston* (SSN 713)

Lt. j.g. Glenn McKenna
USS *Seawolf* (SSN 21)

Lt. j.g. Connor McLemore
USS *Bremerton* (SSN 698)

Lt. j.g. Barry McShane
USS *California* (SSN 781)

Lt. j.g. Thomas McSweeney
USS *Santa Fe* (SSN 763)

Lt. j.g. Curran Meek
USS *Asheville* (SSN 758)

Lt. j.g. Ryan Miller
USS *Jefferson City* (SSN 759)

Lt. j.g. Jan Morales
USS *Tennessee* (SSBN 734) (B)

Lt. j.g. Shane Moran
USS *Montpelier* (SSN 765)

Lt. j.g. Christopher Morgan
USS *San Francisco* (SSN 711)

Lt. j.g. Brett Morris
USS *Chicago* (SSN 721)

Lt. j.g. Eric Mosher
USS *Newport News* (SSN 750)

Lt. j.g. Praveen Murthy
USS *Dallas* (SSN 700)

Lt. j.g. Kristina Nelloms
USS *Michigan* (SSGN 727) (B)

Lt. j.g. Kevin Nguy
USS *Buffalo* (SSN 715)

Lt. j.g. Jeffrey Pang
USS *Asheville* (SSN 758)

Lt. j.g. Weston Patrick
USS *Cheyenne* (SSN 773)

Lt. j.g. Jacqueline Penichet
USS *Michigan* (SSGN 727) (G)

Lt. j.g. Andrew Pfau
USS *Houston* (SSN 713)

Lt. j.g. Julie Plessinger
USS *Minnesota* (SSN 783)

Lt. j.g. Eugene Portner
USS *Newport News* (SSN 750)

Lt. j.g. George Prieto
USS *Missouri* (SSN 780)

Lt. j.g. Michael Protesto
USS *Maryland* (SSBN 738) (B)

Lt. j.g. Eric Provost
USS *Buffalo* (SSN 715)

Lt. j.g. Joseph Puishys
USS *City of Corpus Christi* (SSN 705)

Lt. j.g. Sam Rappeport
USS *Annapolis* (SSN 760)

2017 Submarine Selects

USNA Class of 2017 Submarine Selects wearing their first "official" submarine uniform, called the Flame-Resistant Variant (FRV). First Class Midshipmen Submarine Selects are allowed to wear this, their "Warrior Day" uniform, every Friday from January to Spring Break.

Lt. j.g. Michael Rawls
USS *Michigan* (SSGN 727) (G)

Marcus Rebersak
USS *City of Corpus Christi* (SSN 705)

Michael Reid
USS *Jefferson City* (SSN 759)

Jeremiah Roberts
USS *Asheville* (SSN 758)

Lt. j.g. Cosmas Robless
USS *Buffalo* (SSN 715)

Lt. j.g. Ethan Rockett
USS *Nevada* (SSBN 733) (G)

Lt. j.g. Christopher Rogeness
USS *Alexandria* (SSN 757)

Lt. j.g. Samuel Royster
USS *Charlotte* (SSN 766)

Lt. j.g. Bradley Schanke
USS *Mississippi* (SSN 782)

Lt. j.g. Kara Smith
USS *Virginia* (SSN 774)

Lt. j.g. Matthew Smith
Nuclear Field "A" School

Lt. j.g. Clinton Spencer
USS *Florida* (SSGN 728) (G)

Lt. j.g. Ross Spinelli
USS *Springfield* (SSN 761)

Lt. j.g. Samuel Stern
USS *Virginia* (SSN 774)

Lt. j.g. Daniel Stickles
USS *Tennessee* (SSBN 734) (B)

Lt. j.g. Andrew Sweeney
USS *Ohio* (SSGN 726) (G)

Lt. j.g. Bradley Terbeek
USS *Virginia* (SSN 774)

Lt. j.g. Nathan Thiem
USS *Louisville* (SSN 724)

Lt. j.g. James Thomas
USS *Annapolis* (SSN 760)

Lt. j.g. Andrew Tresansky
USS *Pittsburgh* (SSN 720)

Lt. j.g. Justin Vagts
USS *Scranton* (SSN 756)

Lt. j.g. Danny Varnadore
USS *Maryland* (SSBN 738) (B)

Lt. j.g. Daniel Watts
USS *Pasadena* (SSN 752)

Lt. j.g. Zachary Westlake
USS *Jefferson City* (SSN 759)

Lt. j.g. Joshua Williams
USS *City of Corpus Christi* (SSN 705)

Lt. j.g. Kevin Wilson
USS *Pittsburgh* (SSN 720)

Lt. j.g. Michael Wissehr
USS *Pittsburgh* (SSN 720)

Lt. j.g. Michael Wynveen
USS *Olympia* (SSN 717)

Qualified Nuclear Engineering Officer

Lt. Adam Albrecht
USS *Tucson* (SSN 770)

Lt. Peter Alexakos
USS *Dallas* (SSN 700)

Lt. Marshall Atwood
USS *Rhode Island* (SSBN 740) (B)

Lt. Kevin Aukee
USS *Jimmy Carter* (SSN 23)

Lt. Christian Barresimercado
USS *Alaska* (SSBN 732) (G)

Lt. Nicholas Bell
USS *Texas* (SSN 775)

Lt. j.g. Ryan Benroth
USS *Georgia* (SSGN 729) (B)

Lt. Charles Brand
USS *San Juan* (SSN 751)

Lt. Kyle Brumfield
USS *Alabama* (SSBN 731) (G)

Lt. Coy Bryant
USS *Wyoming* (SSBN 742) (B)

Lt. Matthew Busta
USS *Santa Fe* (SSN 763)

Lt. j.g. Stephen Byrd
USS *Greeneville* (SSN 772)

Lt. Luke Carpenter
USS *Toledo* (SSN 769)

Lt. Vincent Chandler
USS *Olympia* (SSN 717)

Lt. Nicholas Chaung
USS *Asheville* (SSN 758)

Lt. Corey Cicio
USS *Houston* (SSN 713)

Lt. j.g. John Claypool
USS *Charlotte* (SSN 766)

Lt. Patrick Collins
USS *New Mexico* (SSN 779)

Lt. Joseph Couillard
USS *Michigan* (SSGN 727) (G)

Lt. Ty Daniels
USS *Jefferson City* (SSN 759)

Lt. j.g. David Davispope
USS *Ohio* (SSGN 726) (B)

Lt. j.g. Daryl Dietsche
USS *Oklahoma City* (SSN 723)

Lt. j.g. Daniel Doran
USS *Georgia* (SSGN 729) (B)

Lt. Nathan Erxleben
USS *Nevada* (SSBN 733) (G)

Lt. j.g. Lucas Evans
USS *Bremerton* (SSN 698)

Lt. j.g. Brian Fitzgerald
USS *Cheyenne* (SSN 773)

Lt. William Fortin
USS *San Juan* (SSN 751)

COMSUBPAC Winners of 2016 Battle "E" Efficiency Competition Awards:

COMSUBRON 1
USS *Greeneville* (SSN 772)
Cmdr. G. Anseeuw
Lt. Cmdr. R. Hatt (D)
Lt. Cmdr. N. Meyers (R)
STSCM Asleson (D)
ETVCM Martell (R)

SUBDEVRON 5
USS *Jimmy Carter* (SSN 23)
Cmdr. M. Smith
Lt. Cmdr. A. Wilson
CMDCM(SS) Peirsel

COMSUBRON 7
USS *Cheyenne* (SSN 773)
Cmdr. J. Stafford
Lt. Cmdr. J. Johnston (D)
Lt. Cmdr. S. Rumler (R)
STSCS J. Hernandez

COMSUBRON 11
USS *San Francisco* (SSN 711)
Capt. D. Caldwell (D)
Cdr J. Juergens (R)
Lt. Cmdr. R. McCandless
MMACM J. Gruber

COMSUBRON 15
USS *Topeka* (SSN 754)
Cmdr. D. Lammers (D)
Cmdr. S. Tarr III (R)
Lt. Cmdr. R. McDowell
ETVCM M. Schecter

COMSUBRON 17
USS *Alabama* (SSBN 731) (B)
Cmdr. P. Reinhardt
Lt. Cmdr. D. Latta
FTCM T. Leonard

USS *Alabama* (SSBN 731) (G)
Cmdr. M. Chapman
Lt. Cmdr. J. Quimby
MMACM S. Rauch

COMSUBRON 19
USS *Ohio* (SSBN 726) (B)
Capt. B. Berkhout (D)
Capt. D. Soldow (R)
Lt. Cmdr. A. Simons
FTCM S. Bice

Submarine Tender
USS *Frank Cable* (AS 40)
Capt. A. St. John
Cmdr. E. Callahan
CMDCM P. Sweeney

Special Category
USS *Arco* (ARDM 5)
Lt. Cmdr. Z. Harry
Lt. Cmdr. J. Smith
CMDCM S. Jennings

Special Category
Undersea Rescue Command
Cmdr. M. Hazenberg
Lt. Cmdr. J. Babick
HMCM F. Lazarin

Lt. Roberto Rosales
USS *Illinois* (SSN 786)

Lt. Samuel Royster
USS *Charlotte* (SSN 766)

Lt. Bradley Schanke
USS *Mississippi* (SSN 782)

Lt. j.g. Zachary Smith
USS *Maine* (SSBN 741)

Lt. j.g. Danny Varnadore
USS *Maryland* (SSBN 738)

Lt. j.g. Kelly Wendland
USS *Louisiana* (SSBN 743)

Lt. j.g. Eric Wootten
USS *Texas* (SSN 775)

Qualified Submarine Supply Officer

Lt. j.g Jose Gabriel Chirinos
USS *Columbus* (SSN 762)

Lt. j.g Nick Douglas
USS *Pasadena* (SSN 752)

Lt. j.g Louis Gilbert
USS *Columbia* (SSN 771)

Lt. j.g. Jason Herrera
USS *Topeka* (SSN 754)

Lt. Justin Higgins
USS *Alexandria* (SSN 757)

Lt. Annalee Jaques
USS *Texas* (SSN 775)

Lt. j.g Darryl Lindee
USS *Asheville* (SSN 758)

Lt. j.g. Nic Novicov,
USS *Scranton* (SSN 756)

Ens. Justin Kyle Soto
USS *Greeneville* (SSN 772)

Lt. j.g. Samuel Theodoris
USS *Oklahoma City* (SSN 723)

Lt. Tamsyn Thompson
USS *Mississippi* (SSN 782)

Lt. Russell Friedl
USS *Jefferson City* (SSN 759)

Lt. Timothy Gannatti
USS *Hampton* (SSN 767)

Lt. Todd Gerald
USS *Asheville* (SSN 758)

Lt. Evan Greer
USS *Ohio* (SSGN 726) (B)

Lt. j.g. Colter Hanson
USS *Ohio* (SSGN 726) (B)

Lt. Clinton Hawkins
USS *Maine* (SSBN 741) (G)

Lt. Fridolin Heer
USS *Oklahoma City* (SSN 723)

Lt. j.g. Jeremiah Henderson
USS *Greeneville* (SSN 772)

Lt. j.g. Miles Hill
USS *Columbia* (SSN 771)

Lt. j.g. Jordan Holliday
USS *Hartford* (SSN 768)

Lt. Tyler Howell
USS *Maine* (SSBN 741) (G)

Lt. Joseph Hussey
USS *Helena* (SSN 725)

Lt. Kyle Ingram
USS *Toledo* (SSN 769)

Lt. Joshua Jones
USS *Topeka* (SSN 754)

Lt. j.g. Margaret Kelly
USS *Ohio* (SSGN 726) (G)

Lt. Firas Khoury
Strategic Weapons Facility Atlantic

Lt. j.g. Daniel Kindervater
USS *Rhode Island* (SSBN 740) (G)

Lt. Maxwell Koenig
USS *Hartford* (SSN 768)

Lt. Ryan Krady
USS *Columbus* (SSN 762)

Lt. j.g. John Lawler
USS *Hawaii* (SSN 776)

Lt. Justin Leahy
USS *Florida* (SSGN 728) (B)

Lt j.g Maximilian Leutermann
USS *Olympia* (SSN 717)

Lt. j.g. Mark Lindle
USS *Columbus* (SSN 762)

Lt. Garrick Livesay
USS *Georgia* (SSGN 729) (B)

Lt. William Love
USS *Mississippi* (SSN 782)

Lt. Keegan McAllister
USS *Jimmy Carter* (SSN 23)

Lt. j.g. Jacob McDaniel
USS *Nevada* (SSBN 733) (G)

Lt. Daniel McDonald
USS *Michigan* (SSGN 727) (B)

Lt. Bryan McDonough
USS *Ohio* (SSGN 726) (B)

Lt. Praveen Murthy
USS *Dallas* (SSN 700)

Lt. Christian Neal
USS *Maryland* SSBN 738) (G)

Lt. William Pacl
USS *Alabama* (SSBN 731) (G)

Lt. Jeffrey Pang
USS *Asheville* (SSN 758)

Lt. j.g. Alexander Papdakos
USS *Key West* (SSN 722)

Lt. Steven Pascal
USS *Dallas* (SSN 700)

Lt. j.g. Weston Patrick
USS *Cheyenne* (SSN 773)

Lt. Joseph Puishys III
USS *City of Corpus Christi* (SSN 705)

Lt. Sam Rappeport
USS *Annapolis* (SSN 760)

Lt. Nolan Roberts
USS *Michigan* (SSGN 727) (B)

COLORADO (SSN 788) CHRISTENING

Annie Mabus, christens the *Virginia*-class attack submarine USS *Colorado* (SSN 788). Photo by Petty Officer 1st Class Armando Gonzales

On December 3, 2016 USS *Colorado* (SSN 788) was Christened by Ship's Sponsor, Annie Mabus, in ceremonies at General Dynamics Electric Boat Shipyard in Groton, Connecticut.

As an honor the Battleship USS *Colorado* (BB 45), which was christened in 1923 with a bottle of "muddy Colorado River water", December's ceremony featured a sparkling wine produced by Colorado winery Balistreri Vineyards which rested in a bucket filled with ice made from Colorado River water.

Seven veterans of WWII service on Battleship *Colorado* were present and, as part of the ceremony, presented to the crew pens made of teak decking salvaged from the battleship when it was decommissioned in 1947.

After a blessing by Father Anthony Dinoto, the ceremony concluded with the breaking of the bottle of sparkling wine with the traditional words "In the name of the United States, I Christen thee *Colorado*. May God bless her and all who sail in her."

Photo by Robert Tuck

USS *Blueback* (SS 581)
Portland, Ore.

When the *Blueback* was launched in 1959, she was the last diesel-electric submarine to be commissioned by the U.S. Navy. Of the three *Barbel*-class submarines, the *Blueback* is the only one still existing.

USS *Blueback* was launched in May 1959 with Lt. Cmdr. Robert Gautier in command. Ingalls Shipbuilding Corp. had never built a submarine before—in fact, no shipyard in the entire southern United States had built a submarine since the early attempts during the Civil War.

After being commissioned on October 15, 1959, the boat went through a short "fitting out" period of arming and crewing before heading out in 1960 to San Diego. There she performed acceptance trials and training runs before relocating to Pearl Harbor. In 1965, she was deployed to assist American operations in Vietnam where she served three tours of duty. *Blueback* spent the next decade patrolling the Pacific and running special assignments in the Far East. In return for her service, *Blueback* was awarded two battle stars for participating in high-profile engagements during Vietnam. Unfortunately, much of *Blueback*'s operational history is still classified. Never the less, her superior engineering allowed the crew to complete a wide variety of reconnaissance and covert operations.

During *Blueback*'s 30 years of service, she and her crew were proud to represent the Submarine Force and the United States in many noteworthy events, including significant international naval exercises. Domestically, for example, she represented the Submarine Force at SUBASWEX. and overseas she participated at RIMPAC '75, RIMPAC '77, and RIMPAC '84, sailed to Australia to participate in the anniversary of the Battle of the Coral Sea, and also visited Colombia, South America where she joined Task Force 138 for exercises at UNITAS XVIII.

During her service history, the USS *Blueback* was modified by the Navy to incorporate the latest technologies; however, these modifications did not negatively impact the boat's character-defining features or significance. The most notable modification was the relocation of the dive planes from the vessel's bow to the sail in 1964.

As a testament to the excellence of the Sailors who served on the *Blueback*, she earned a Meritorious Unit Commendation and three Battle "E" Efficiency awards.

The *Blueback* was decommissioned in 1990 and donated in 1994 to the Oregon Museum of Science and Industry (OMSI) in Portland. The museum staff has carefully restored the boat to its in-service appearance, altering only what was necessary to make the boat accessible to the public.

www.omsi.edu/submarine